Decadal Climate Forecasting for West Africa

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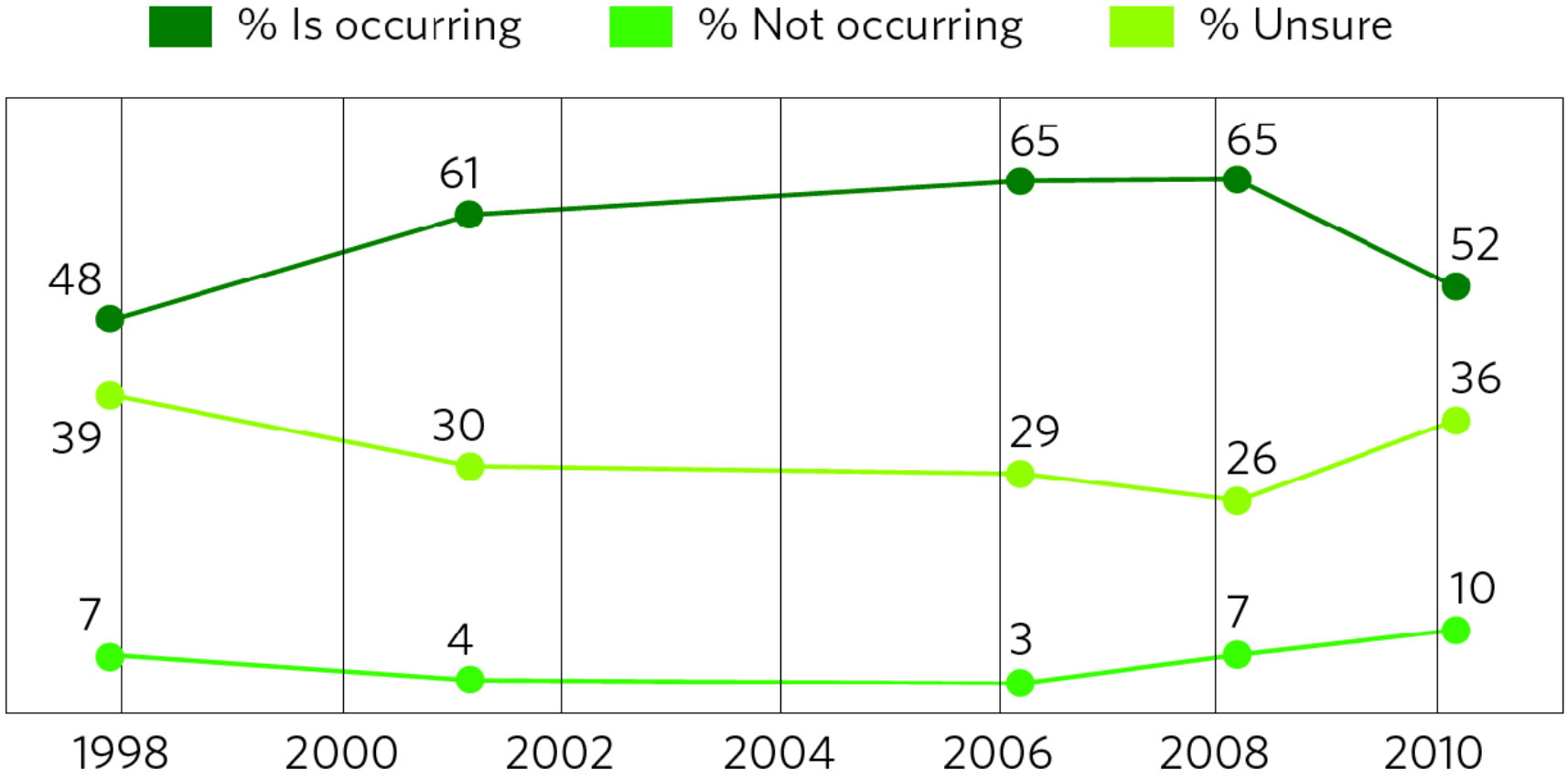
What this presentation is not about

Results to asking the question "which one of the following statements is most accurate: most scientists believe that global warming is occurring, most scientists believe that global warming is not occurring, or most scientists are unsure about whether global warming is occurring or not?"



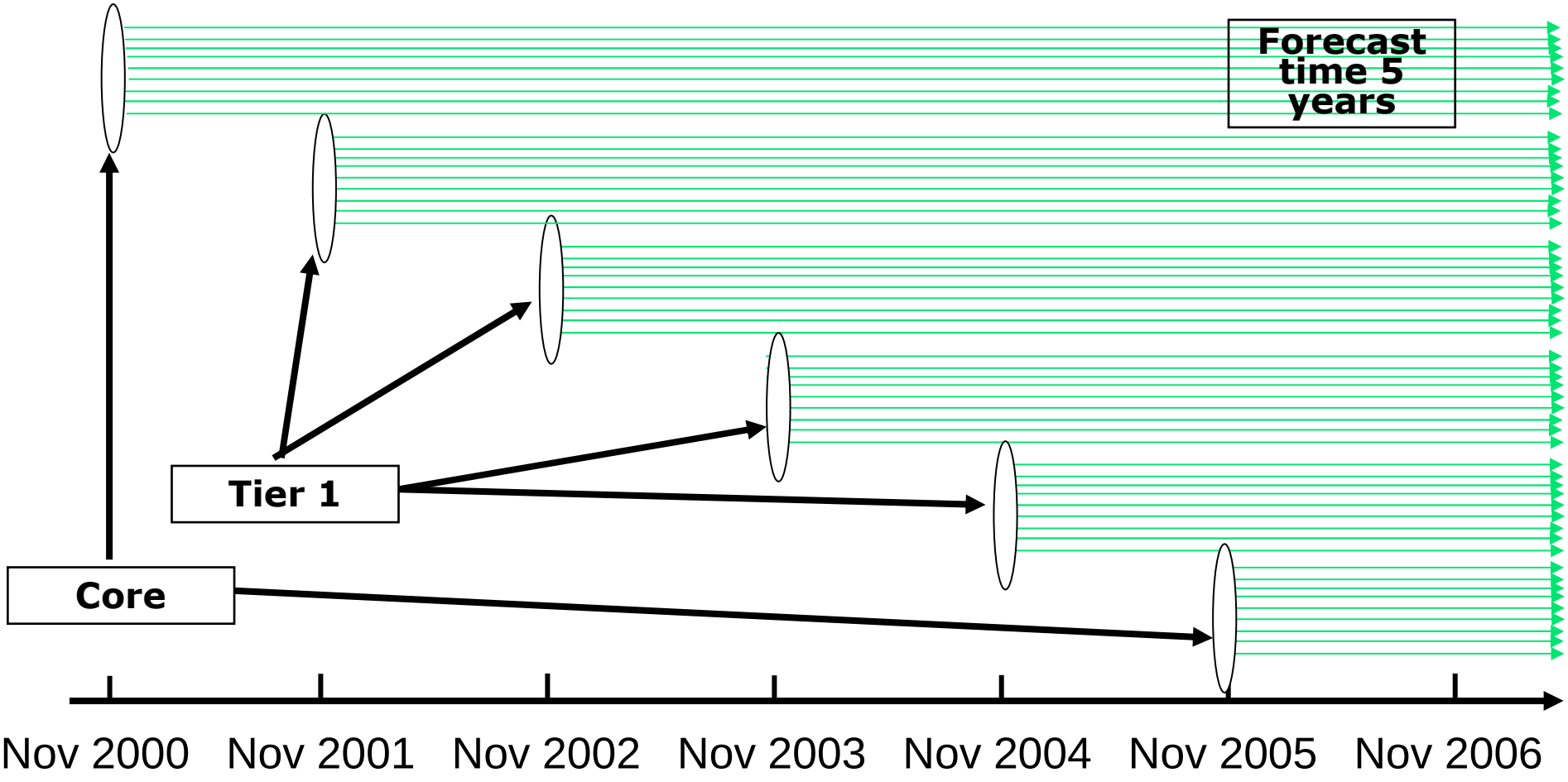
Pidgeon and Fischhoff (2011)

Formulating near-term predictions

- Near-term climate predictions make use of information related to anthropogenic climate change, natural forcings and natural variability.
- Empirical models
  - Characterize the observed variability of the past
  - Relies on reasonably good and long observational datasets
- Long-term climate change simulations
  - Ensembles of historical simulations and long-term projections, preferably multi-model
  - All bells and whistles forcings, but no initial-condition information
- Initialized predictions
  - Made with coupled Earth System Models with initialization of the climate system, particularly the oceans
  - Include observed and projected changing atmospheric composition

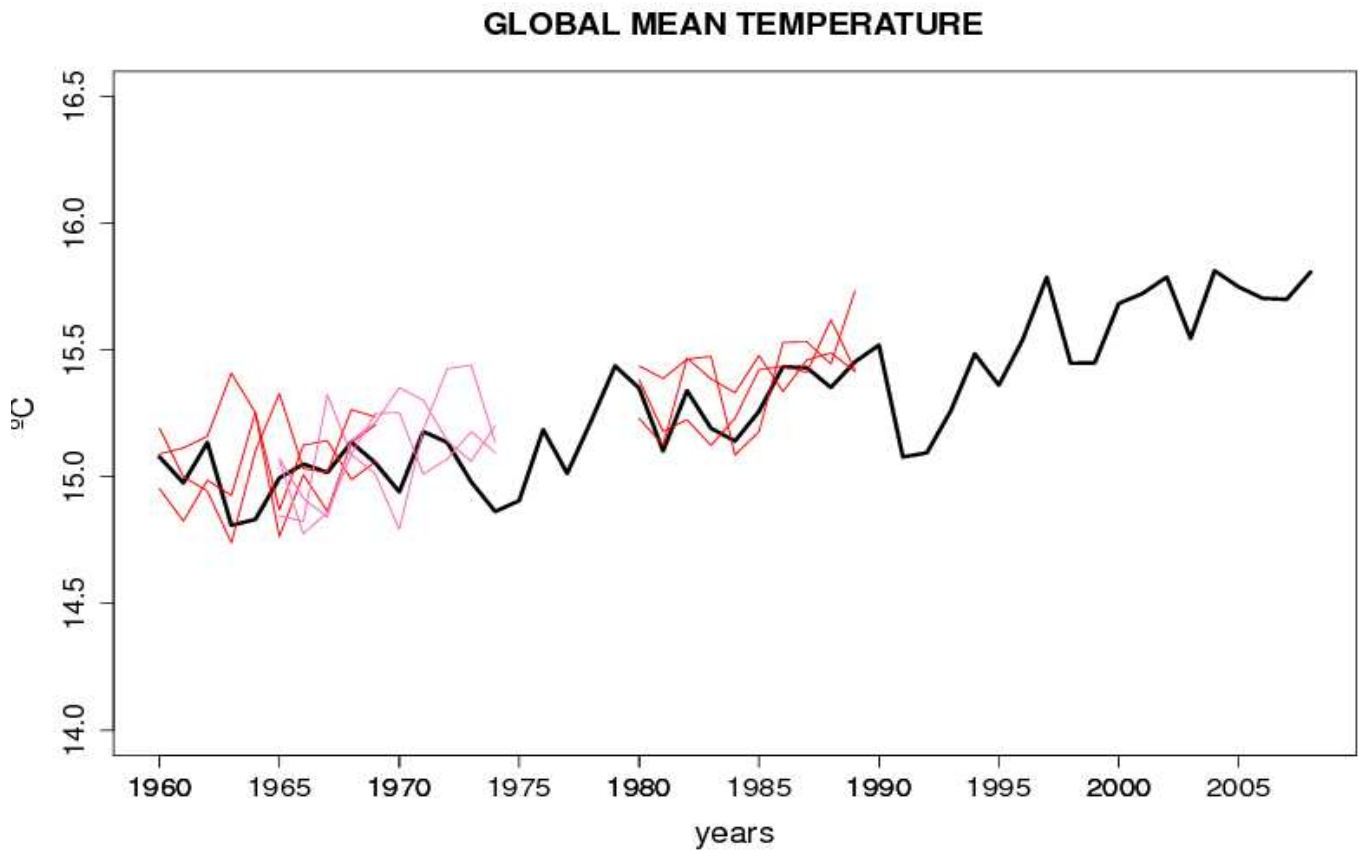
Ensemble initialized near-term predictions

CMIP5: ensemble forecast systems using an initialized ESM

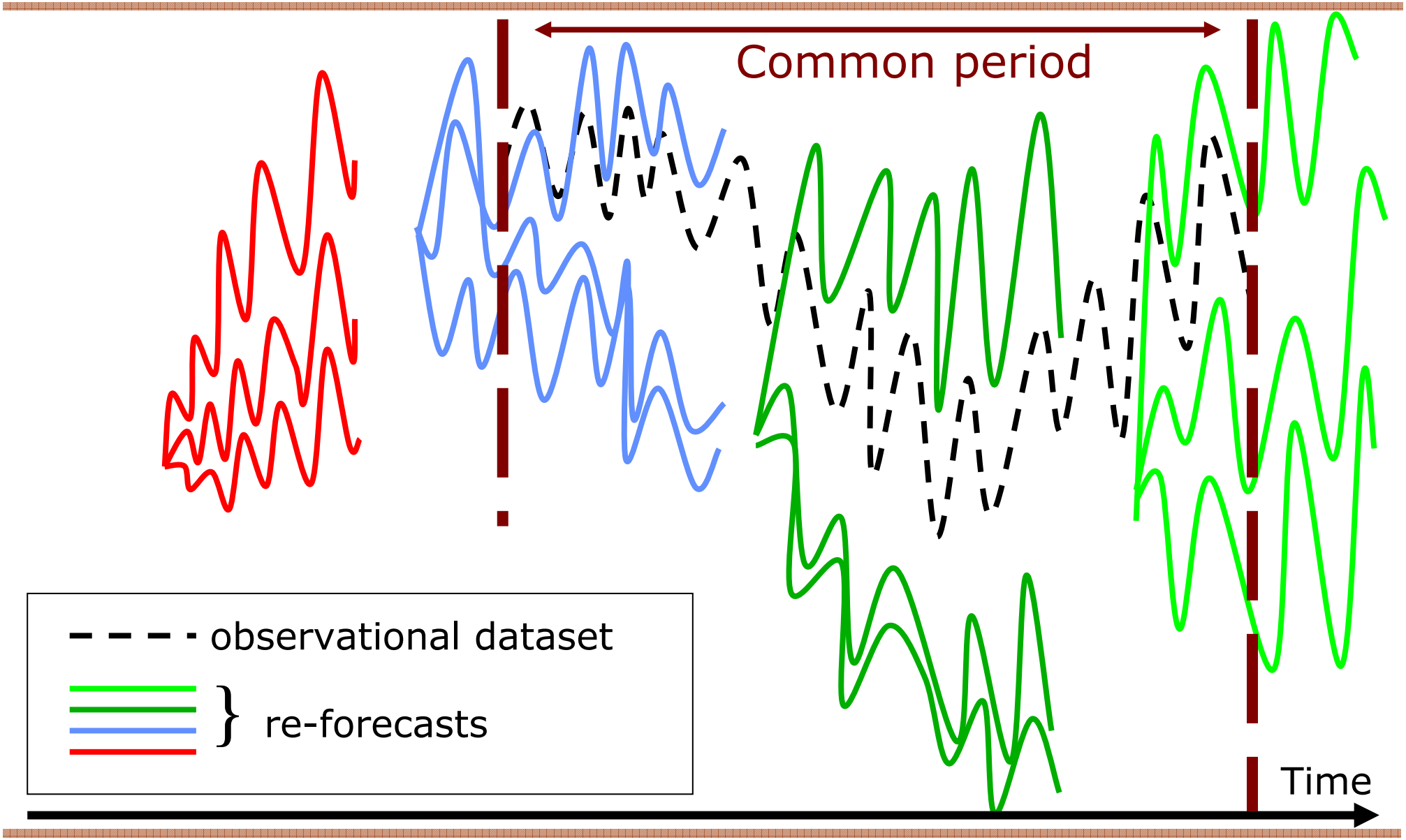


Ensemble initialized near-term predictions

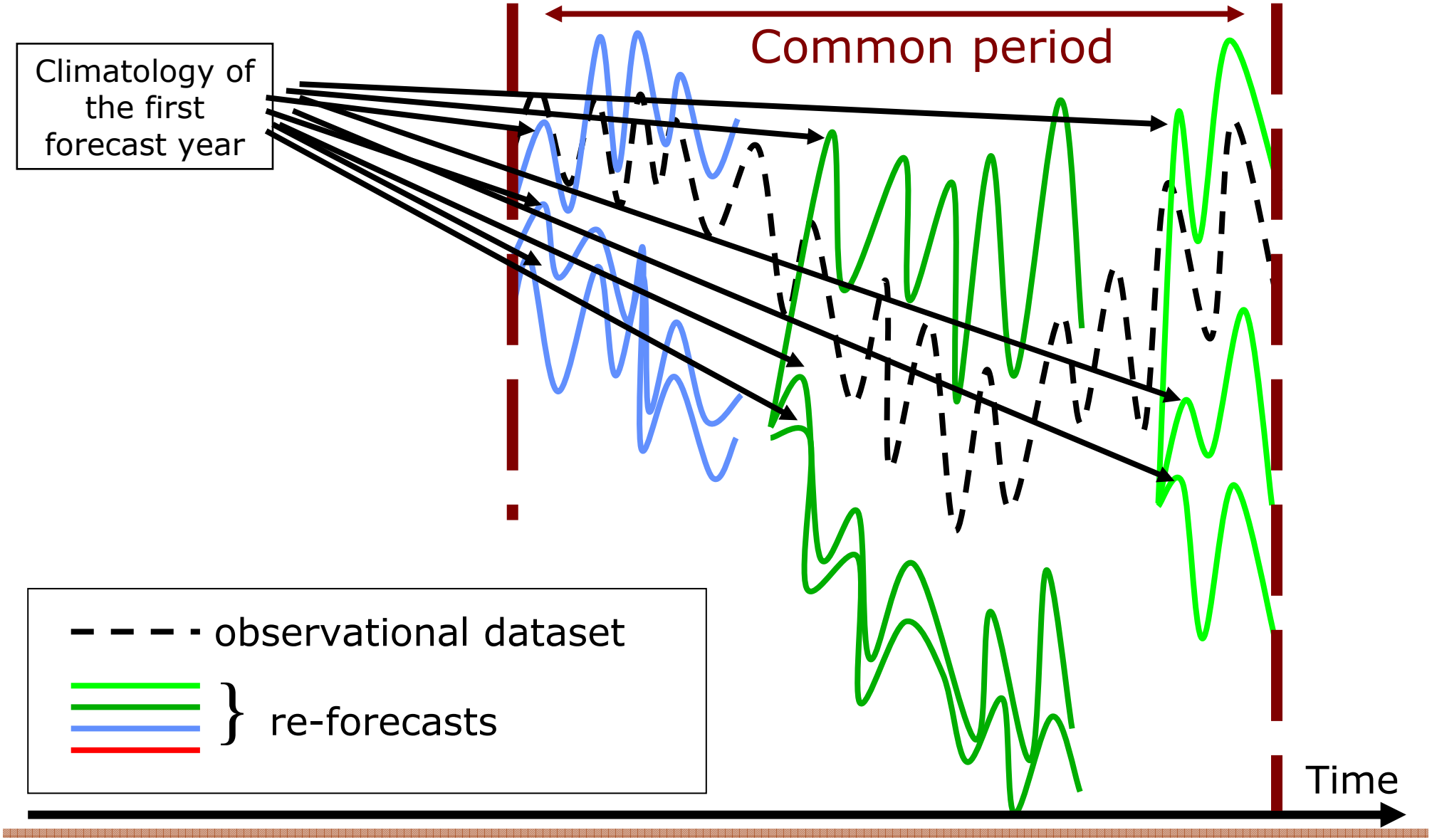
Idealized ensemble forecast system with an initialized ESM



Estimating the climate



Estimating the climate



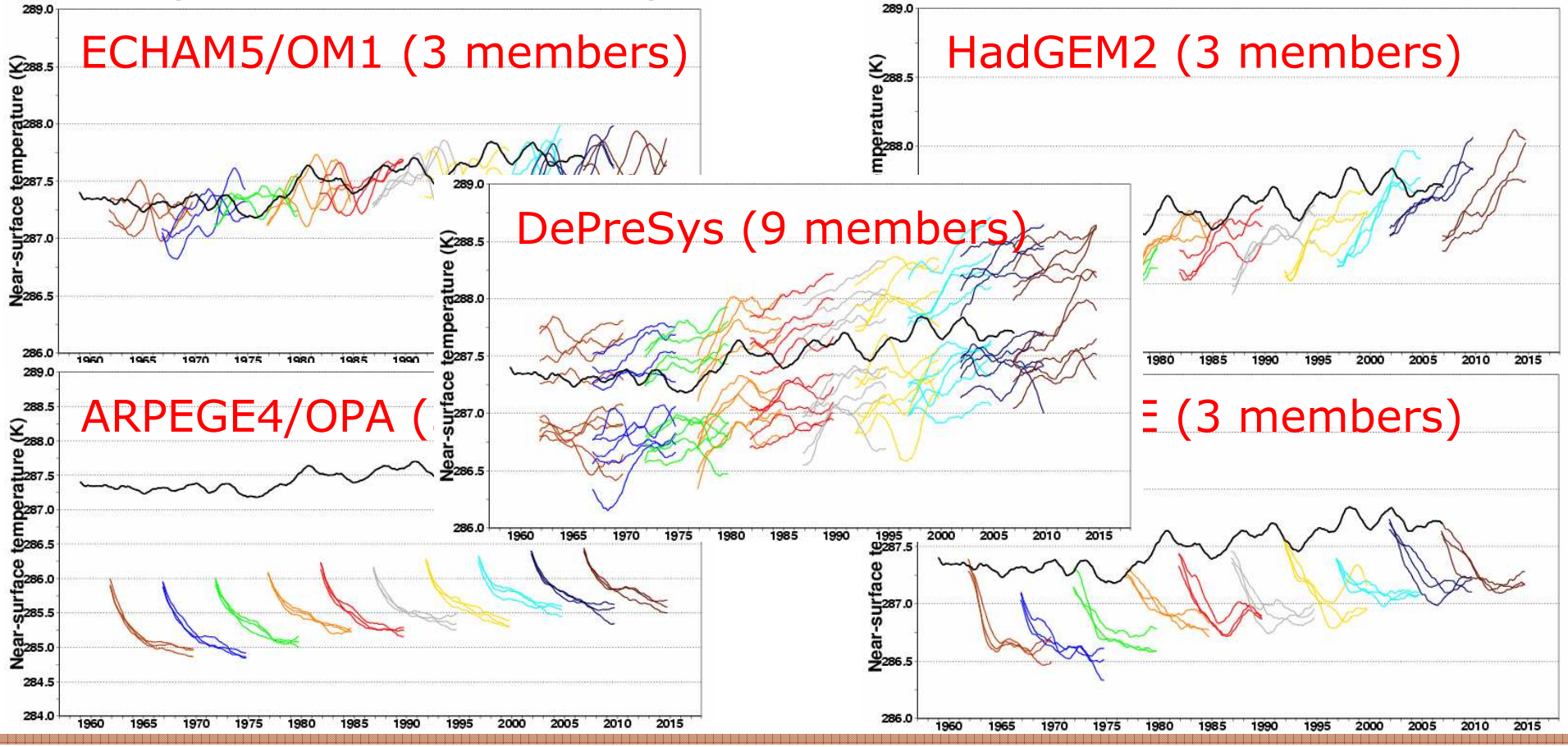
ENSEMBLES decadal forecasts

- Decadal forecasting with dynamical Earth System Models carried out with initialized coupled forecast systems.
- Model uncertainty is a major source of forecast error. Two approaches address model uncertainty on forecast error in ENSEMBLES: multi-model (ECMWF, CERFACS, IfM-Kiel, HadGEM2) and perturbed parameters (DePreSys_PP).
- Experimental setup:
  - Multi-model Stream 2: 10-year 3-member ensemble runs over 1960-2005 initialized the 1st November every 5 years (10 re-forecasts); initial conditions taken from ERA-40 and ocean re-analyses (ECMWF, CERFACS, HadGEM2) and SST-nudged initialization (IfM-Kiel).
  - DePreSys_PP Stream 2: 10-year 9-member ensembles started once a year and 30-year runs every 5 years; initial conditions compatible with the model climate (anomaly initialization) and use of flux corrections.

ENSEMBLES: global T_s

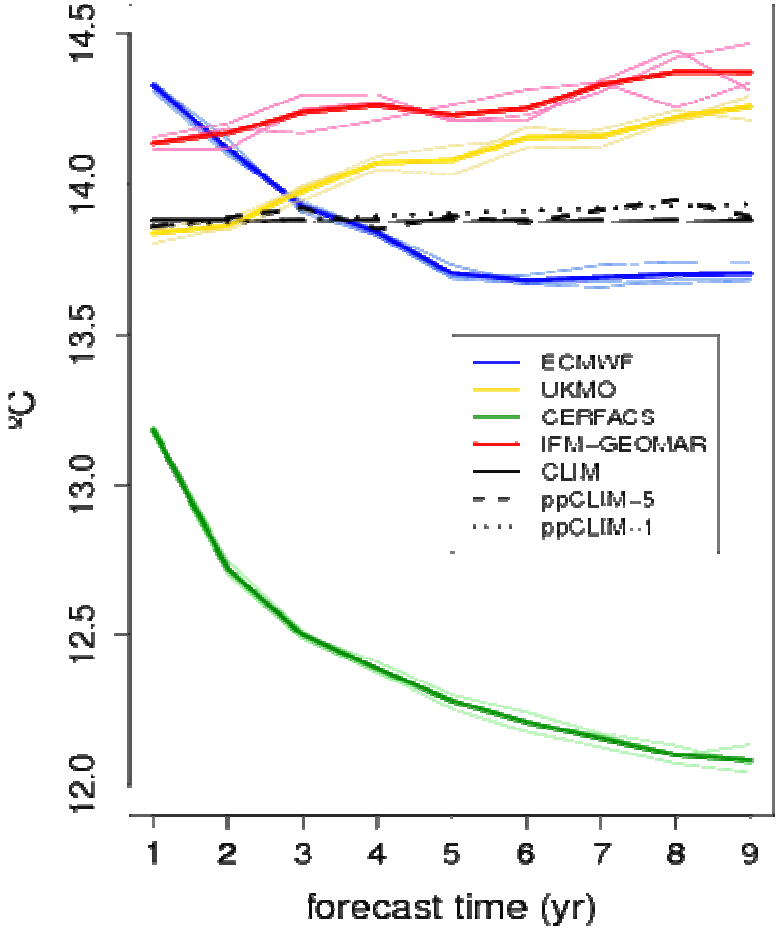
Global mean near-surface air temperature (2-year running mean applied) from the ENSEMBLES re-forecasts. Each hindcast is shown with a different colour. ERA40/Int is used as reference.

The systematic error is very different from one system to another.



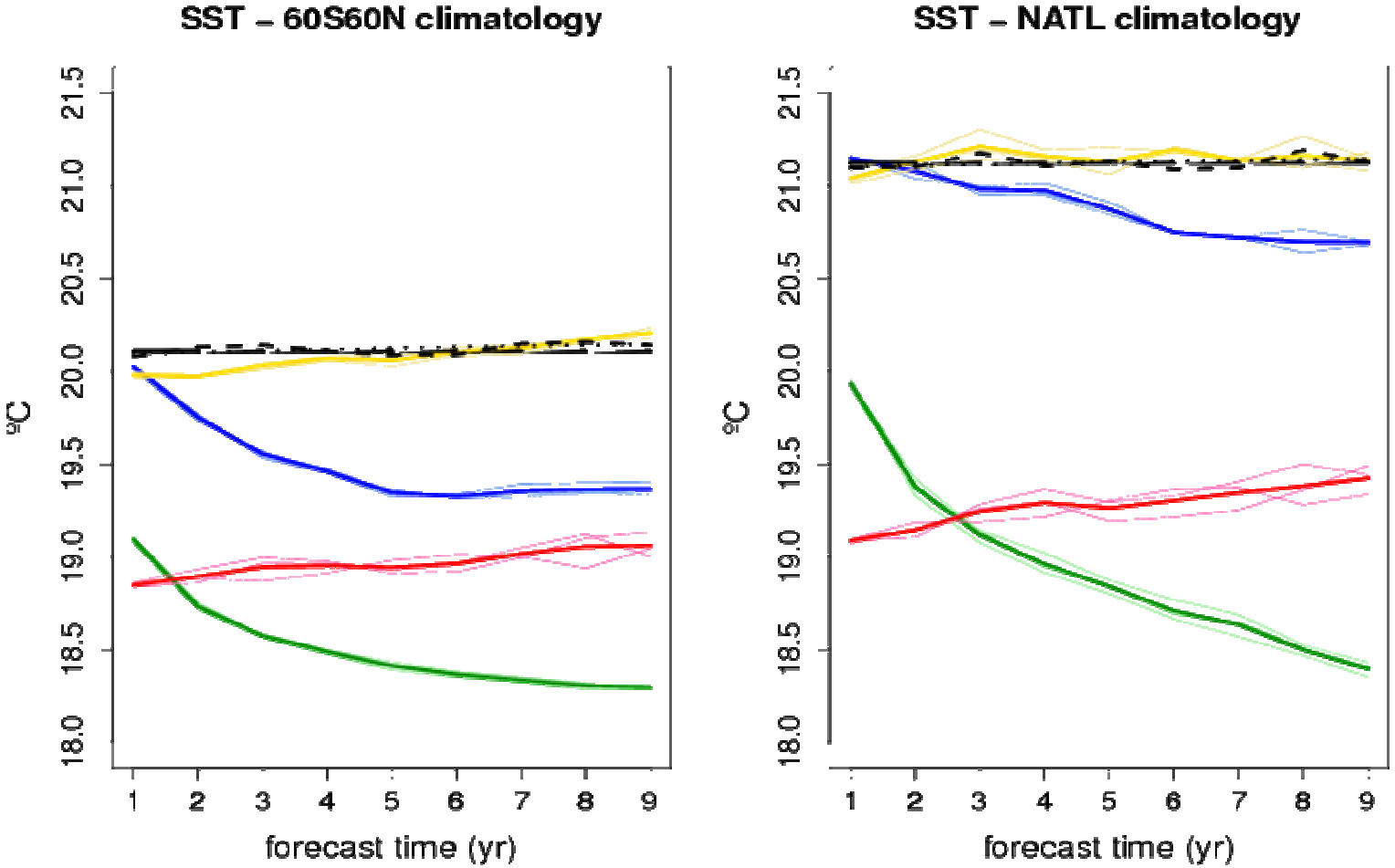
ENSEMBLES: drift

Climatology of the global mean near-surface air temperature. ERA40/Int is used as reference and plotted with a constant climatology along forecast time (solid) and one (dashed and dotted) depending on forecast time.



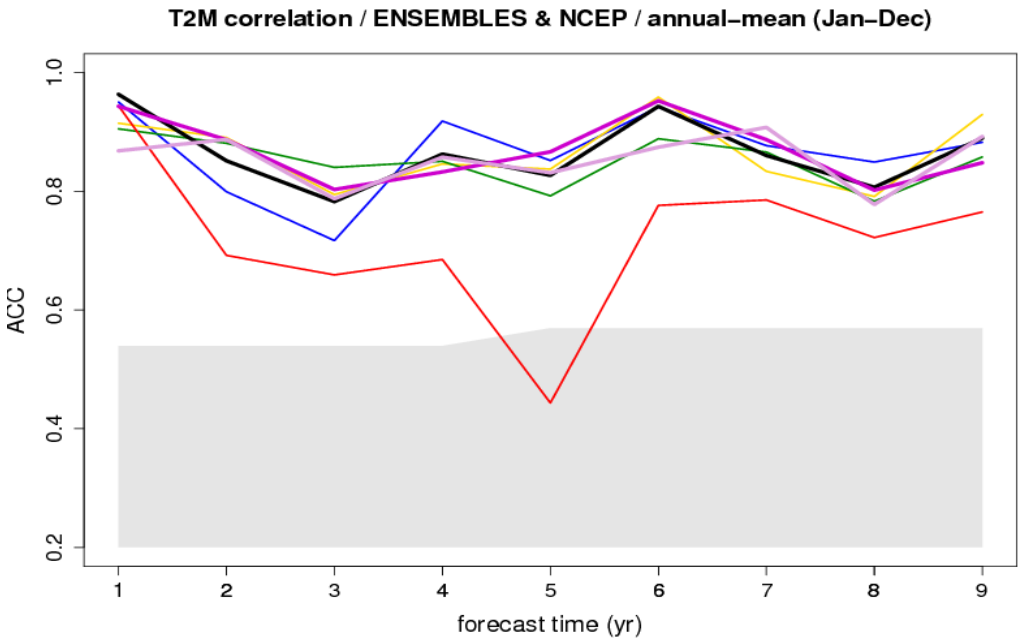
ENSEMBLES: global T_s drift

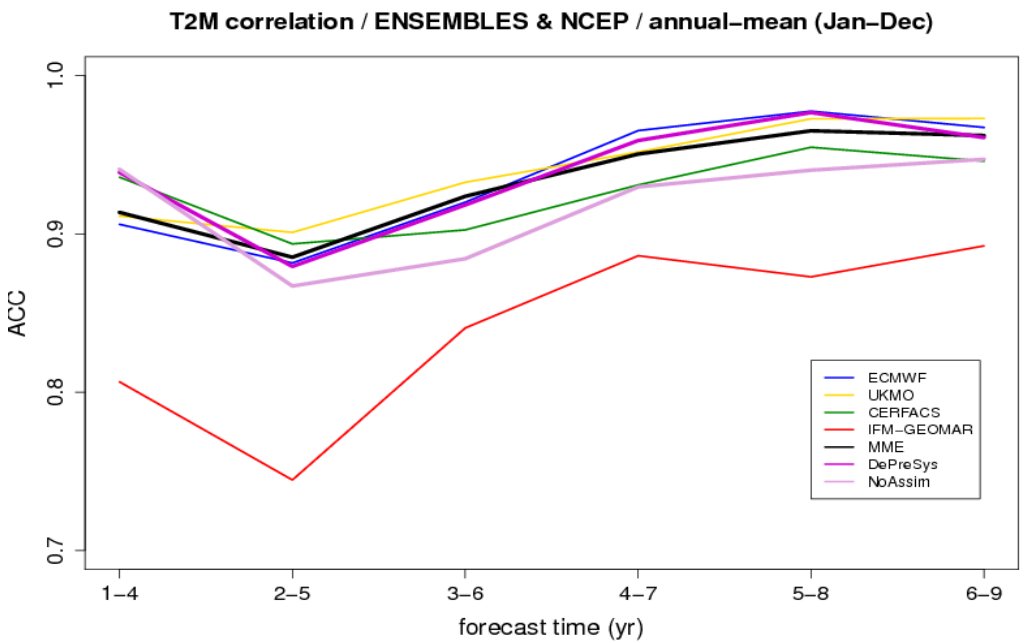
Climatology of the global mean and North Atlantic average SSTs. ERSST is used as reference and plotted with a constant climatology along forecast time (solid) and one (dashed and dotted) depending on forecast time.



ENSEMBLES: global T_s skill

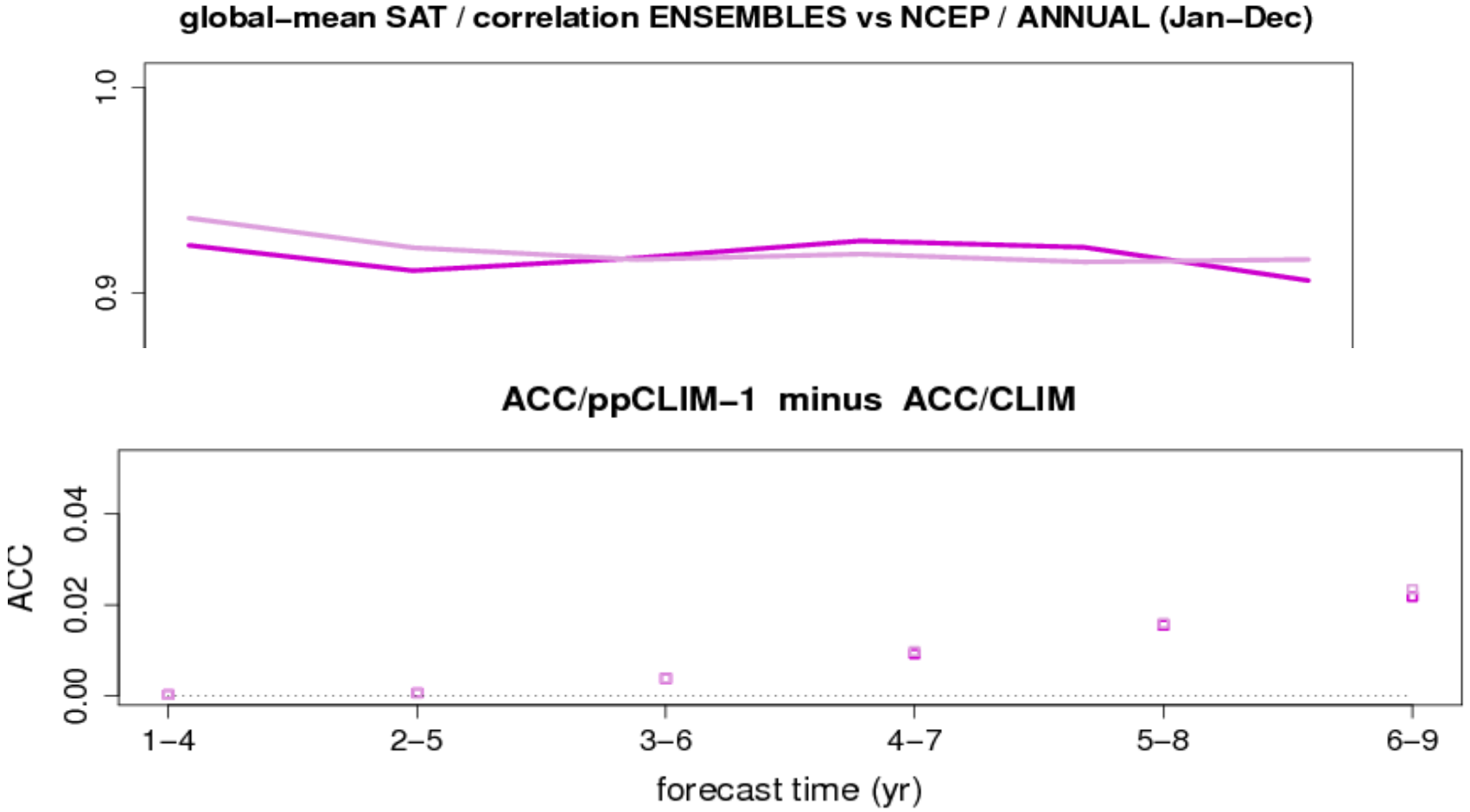
Annual-mean, ensemble-mean correlation for the global-mean near-surface temperature with respect to the NCEP reanalysis. The grey band corresponds to the 95% confidence interval.





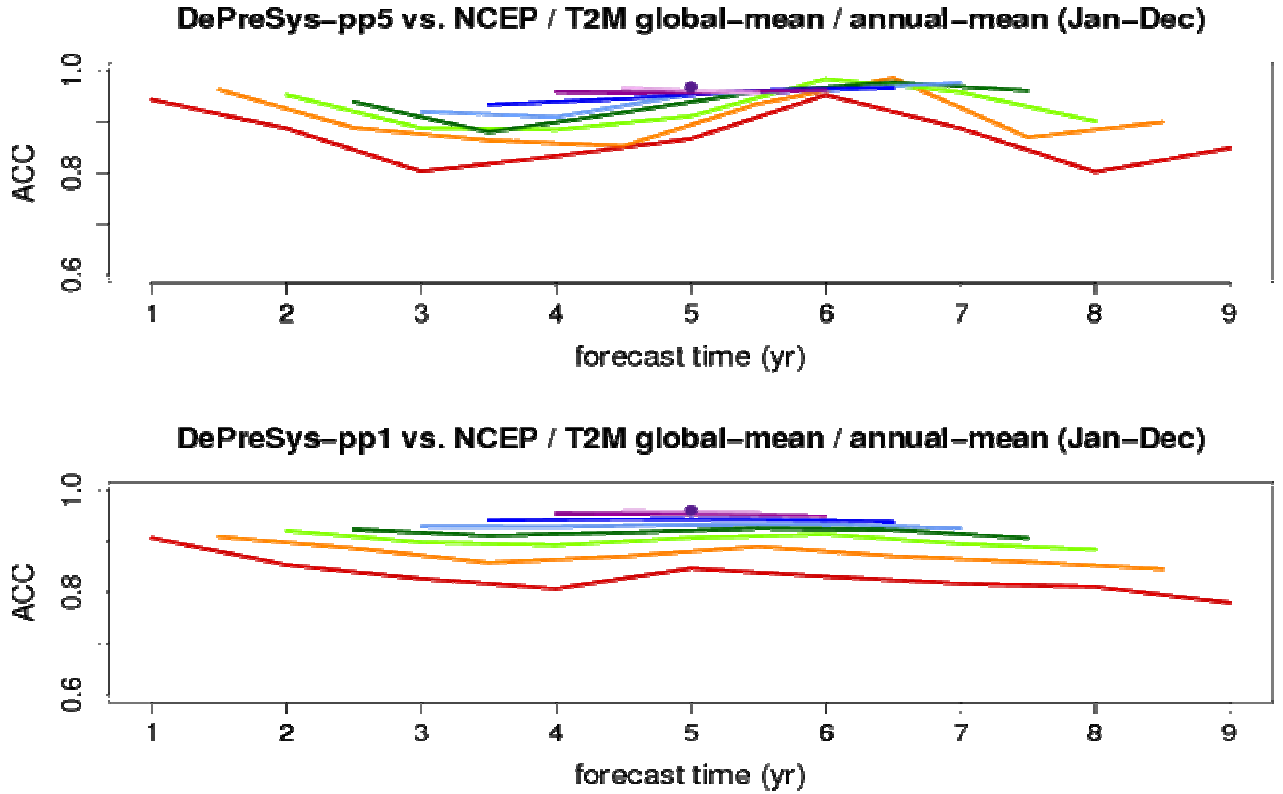
Impact of start date frequency

Annual-mean, ensemble-mean correlation with respect to the NCEP reanalysis for the global-mean near-surface temperature of DePreSys Assim (purple) and NoAssim (pink) with one start date per year.



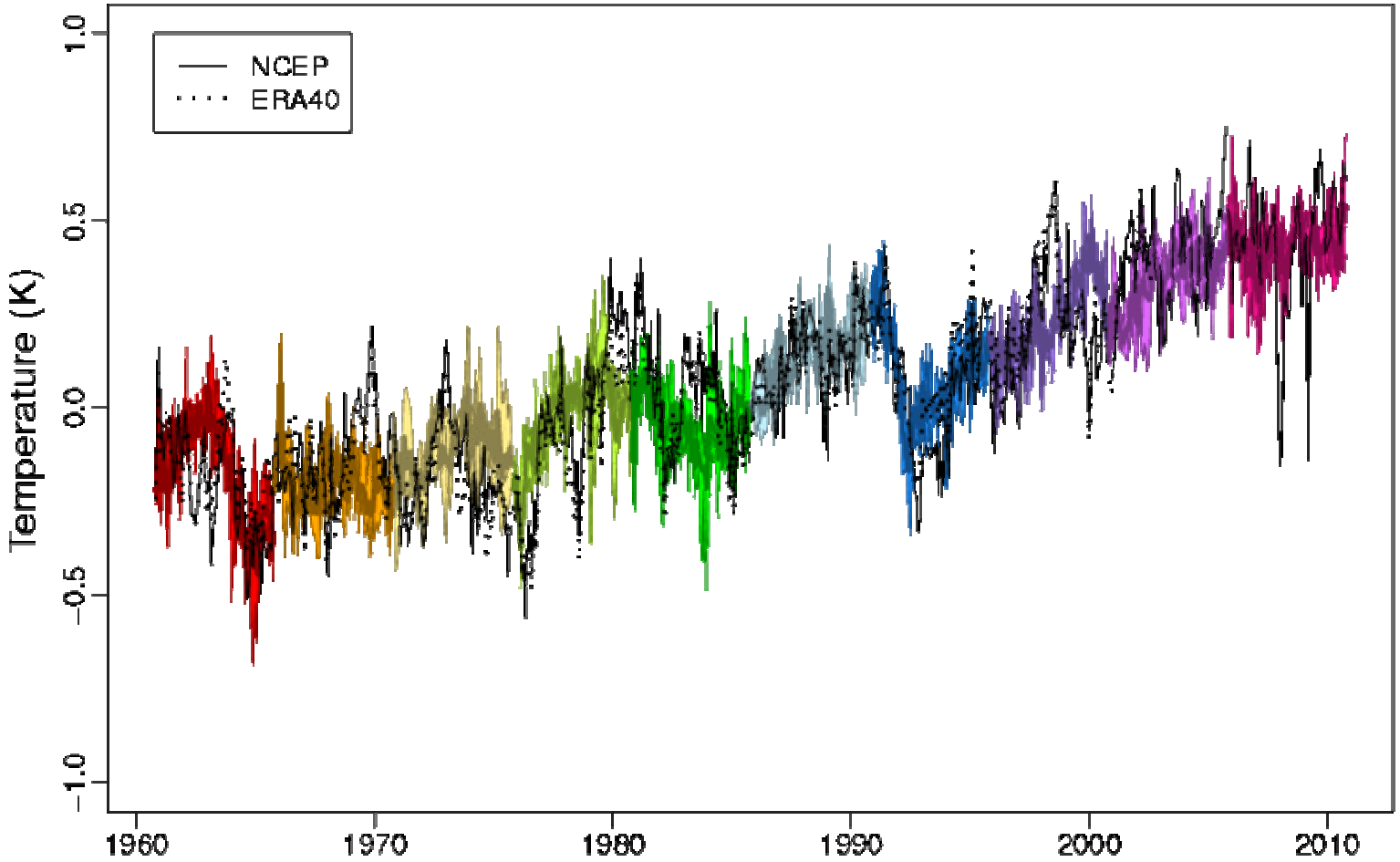
Impact of start date frequency

Annual-mean, ensemble-mean correlation with respect to the NCEP reanalysis for the global-mean near-surface temperature for DePreSys Assim with one start date every five years (top) and every year (bottom). Each colour shows the result for a different degree of averaging, from red (one year) to purple (nine years).



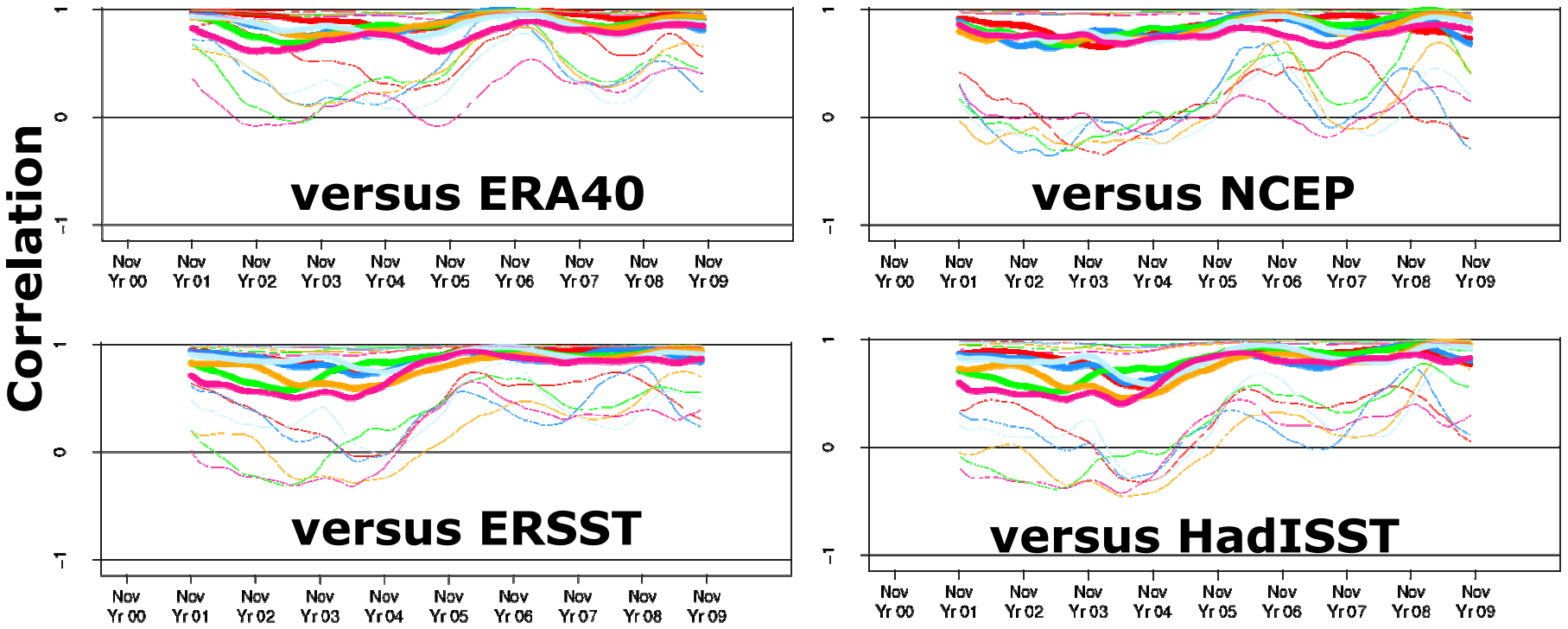
CMIP5 decadal experiments

Global-average near-surface air temperature ensemble (three members) re-forecasts performed with EC-Earth v2.3 over 1960-2005 (IC3, full initialization).



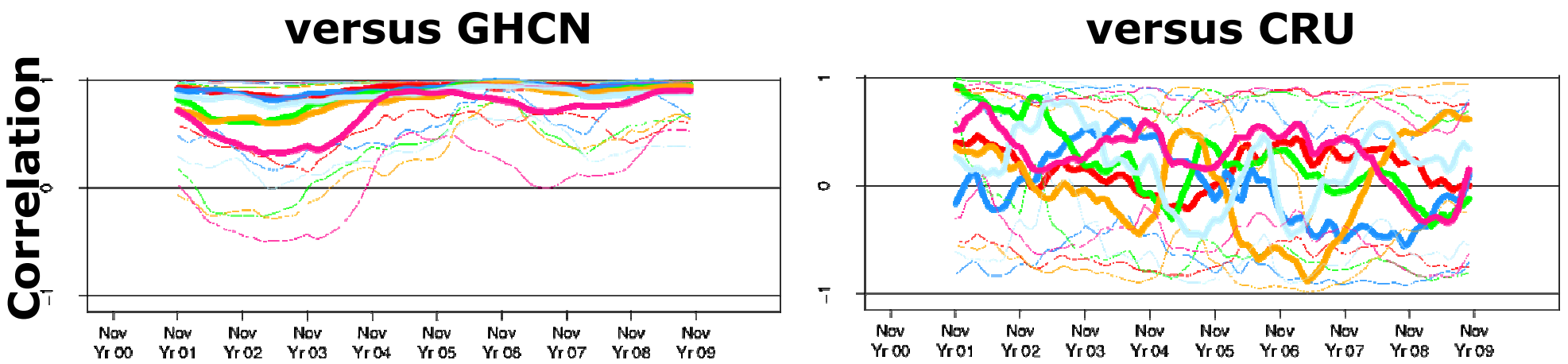
CMIP5 decadal predictions

Ensemble-mean correlation (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) global-average near-surface air (top row) and sea surface (65ºN-60ºS, bottom row) temperature re-forecasts (two-year running mean applied) over 1960-2005.



Several decadal predictions

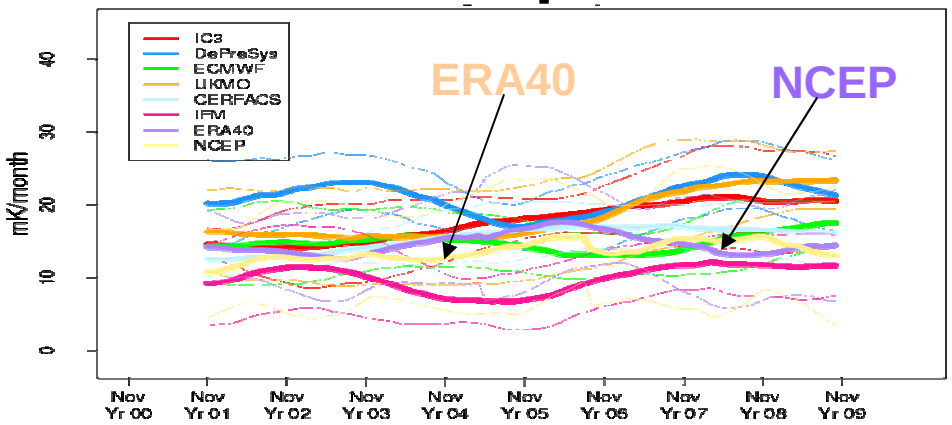
Ensemble-mean correlation (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) land-average temperature (left) and precipitation (right) re-forecasts (two-year running mean applied) over 1960-2005.



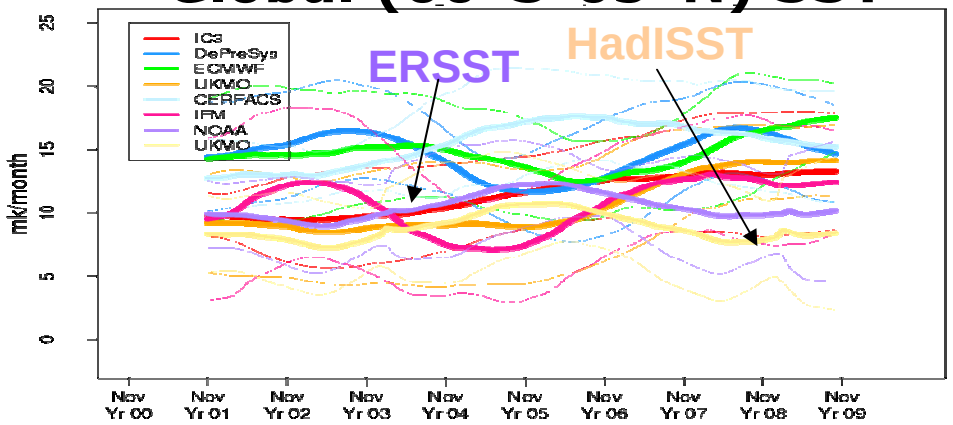
CMIP5 decadal predictions

Linear trends (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) re-forecasts (two-year running mean applied) over 1960-2005.

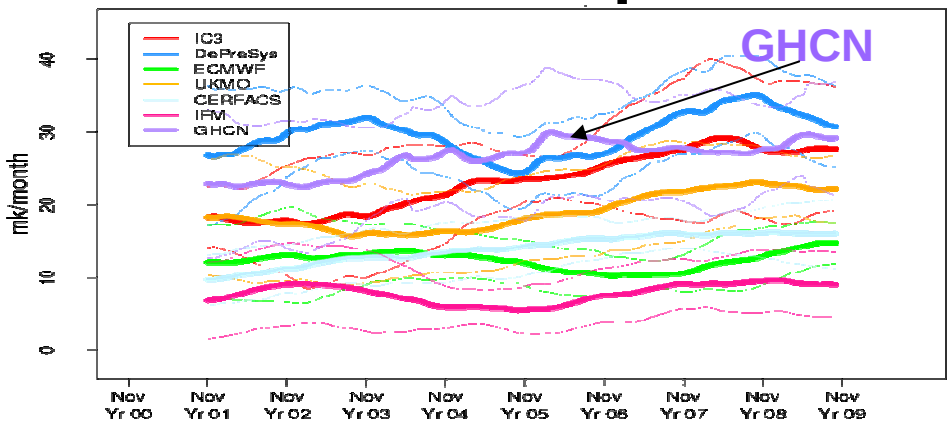
Global temperature



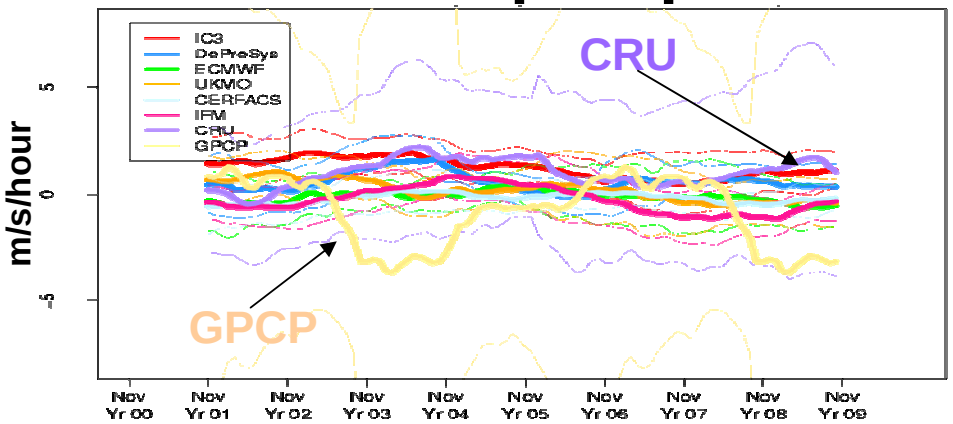
Global (60°S-65°N) SST



Global land temperature



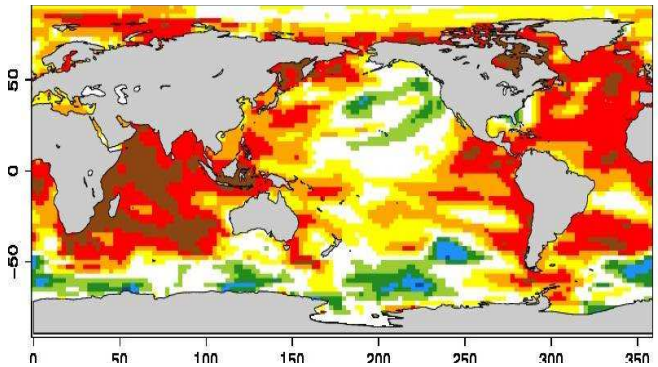
Global land precipitation



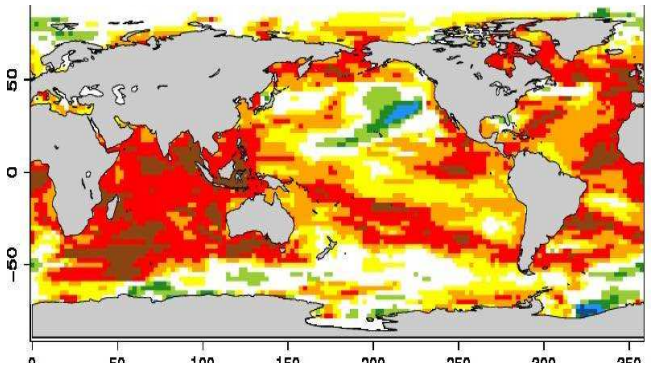
SST decadal predictions

Single-system ensemble-mean correlation for decadal forecasts (2-5 year average) of SSTs (1960-2005) wrt ERSST.

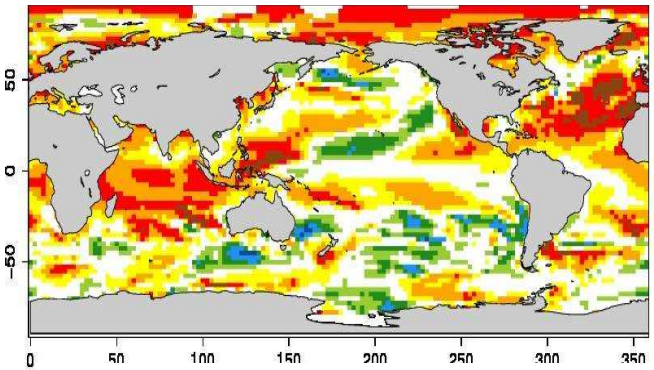
CERFACS



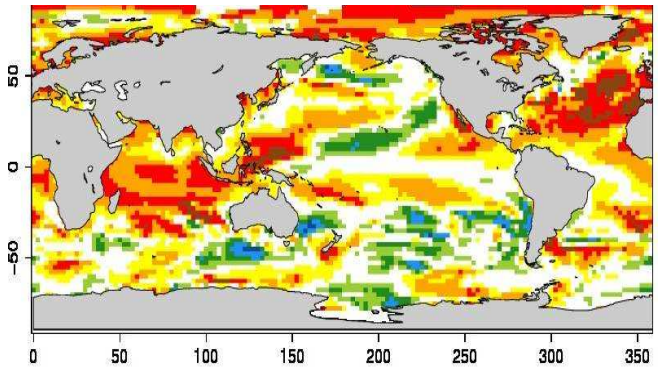
UKMO



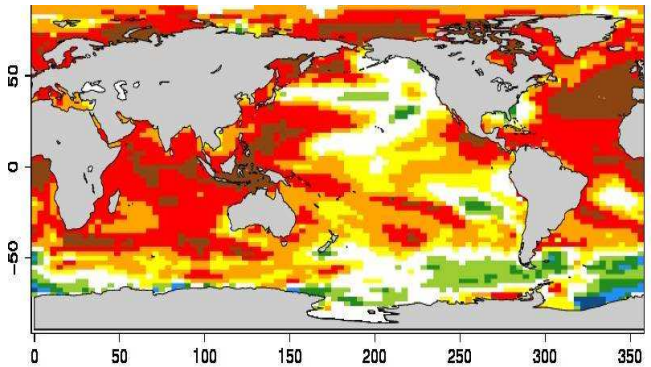
IFM-GEOMAR



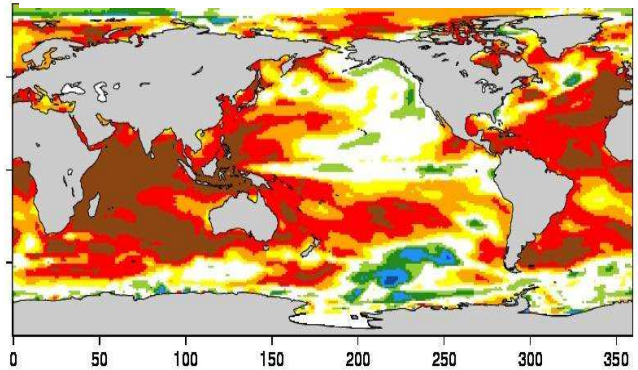
ECMWF

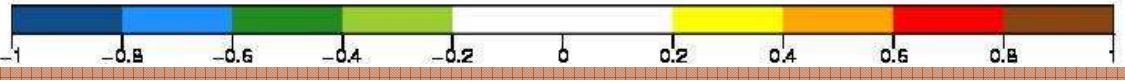


DePreSys



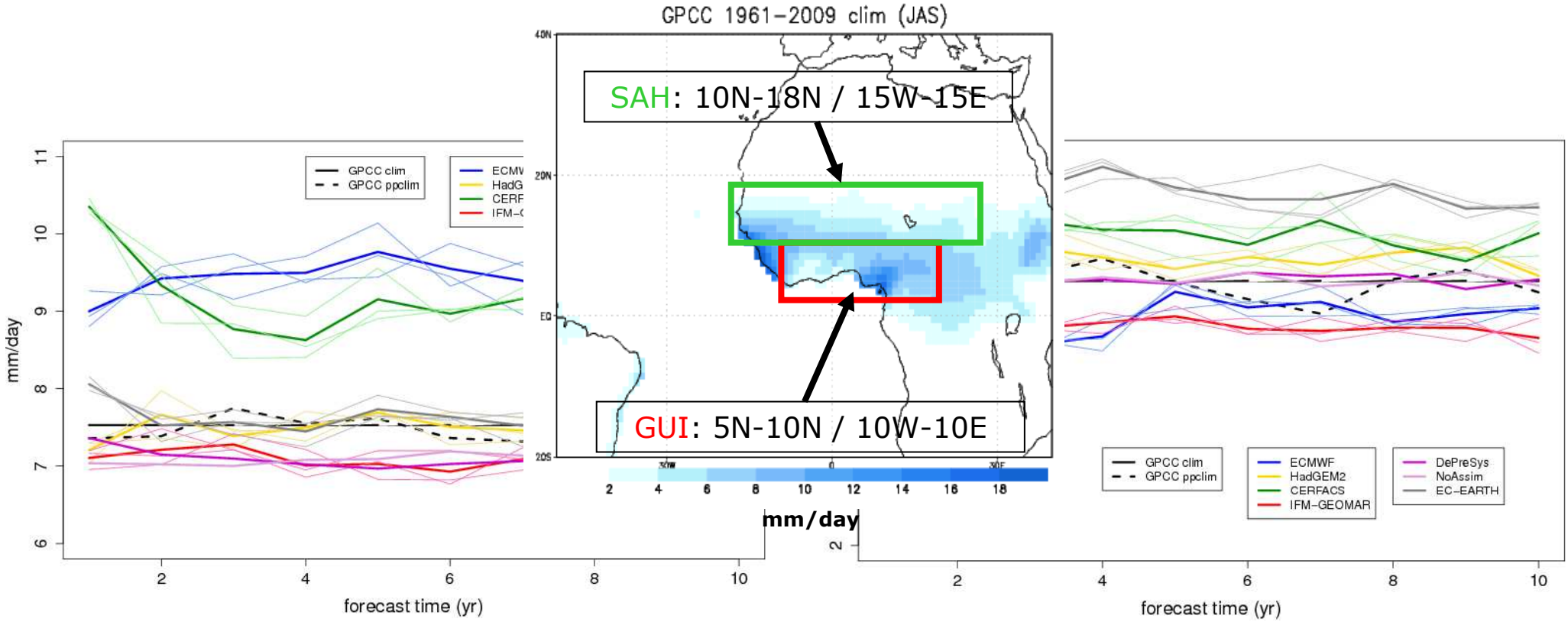
EC-Earth





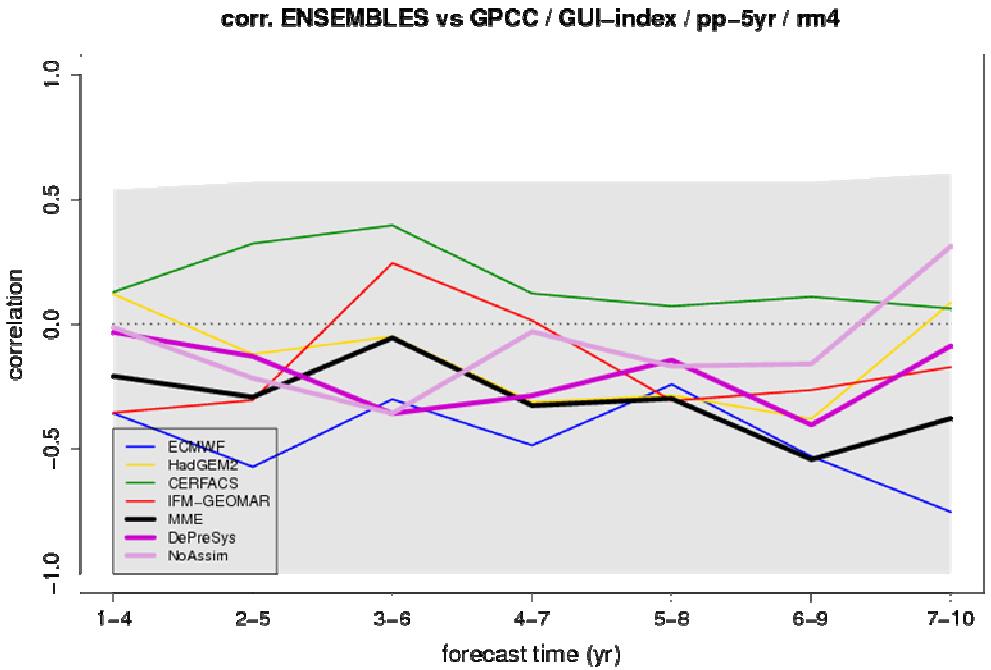
West African precipitation

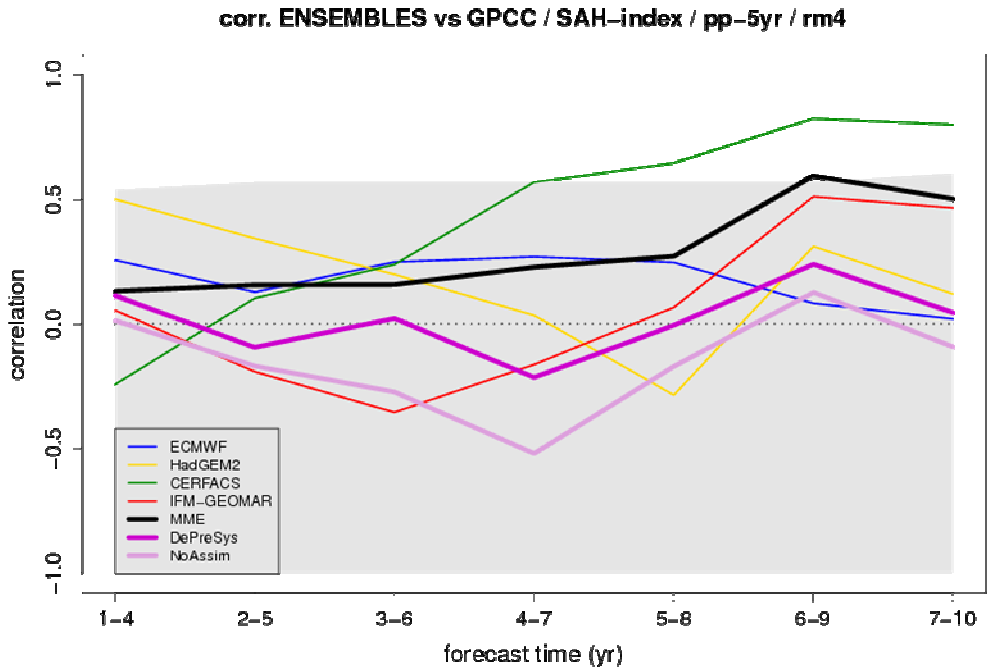
Guinean (5ºN-10ºN, 10ºW-10ºE, left) and Sahel (10ºN-18ºN,15ºW-15ºE, right) average JAS precipitation for the ENSEMBLES multi-model, DePreSys_PP and EC-Earth CMIP5 predictions. The two ways of estimating the observed climatology are illustrated in black.



West African precipitation

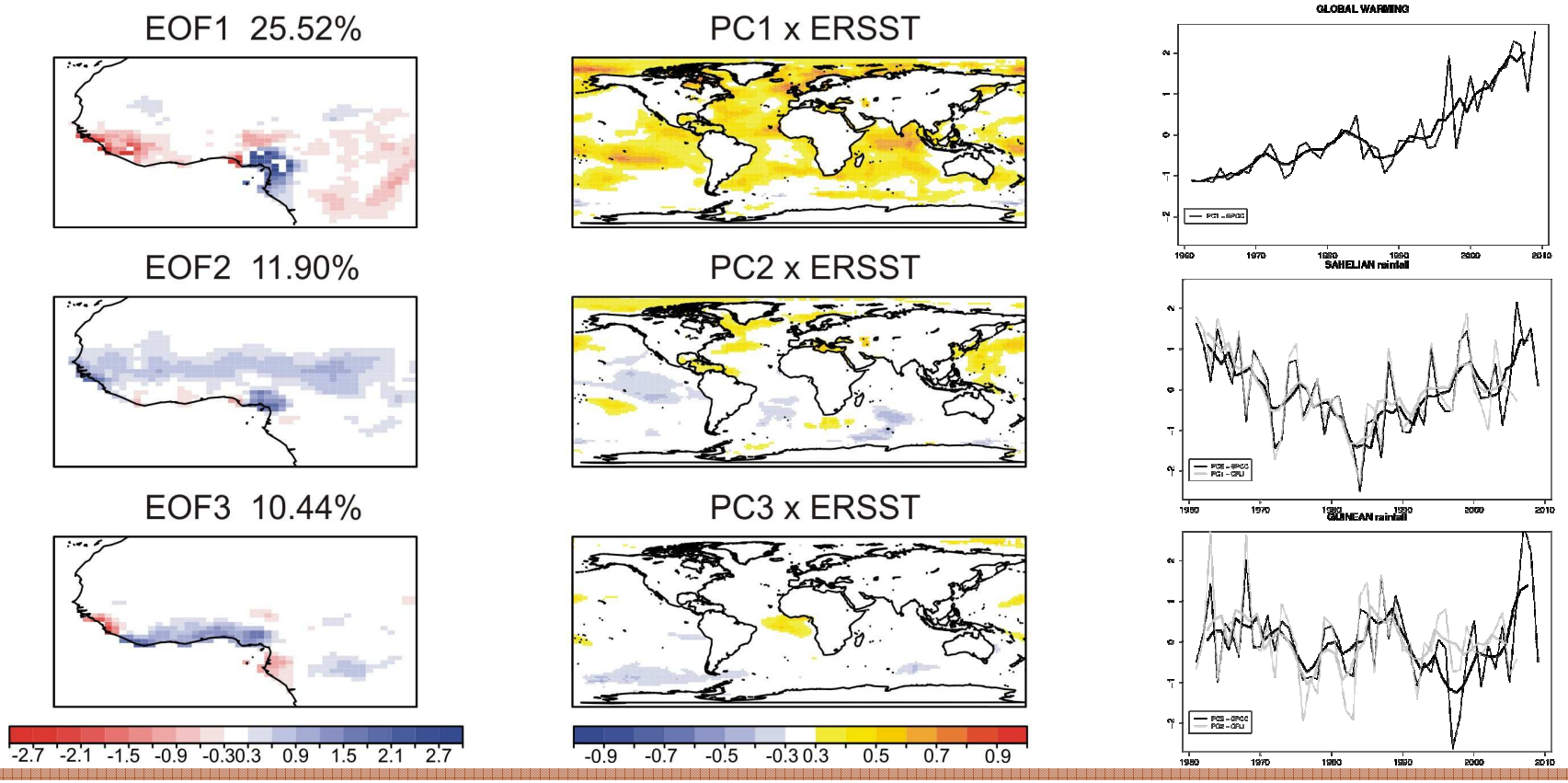
Guinean (5ºN-10ºN, 10ºW-10ºE, left) and Sahel (10ºN-18ºN,15ºW-15ºE, right) ensemble-mean JAS precipitation correlation with GPCC for the ENSEMBLES multi-model and DePreSys_PP Assim and NoAssim predictions. The grey band corresponds to the 95% confidence interval.





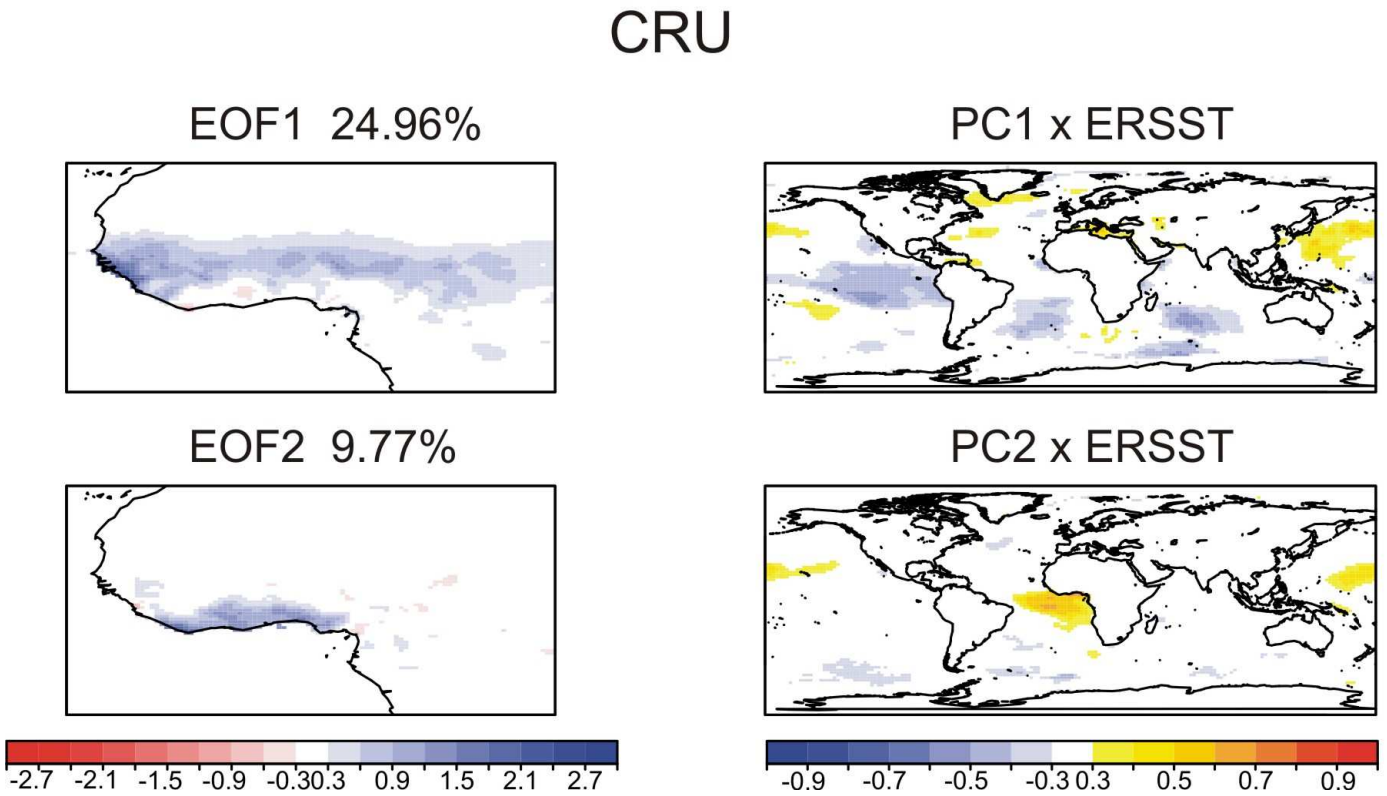
West African precipitation

Spatial pattern, correlation with the SSTs and time series (with five-year running mean and comparison with the equivalent modes from CRU) of the three leading modes of the GPCC JAS precipitation over the period 1960-2005.



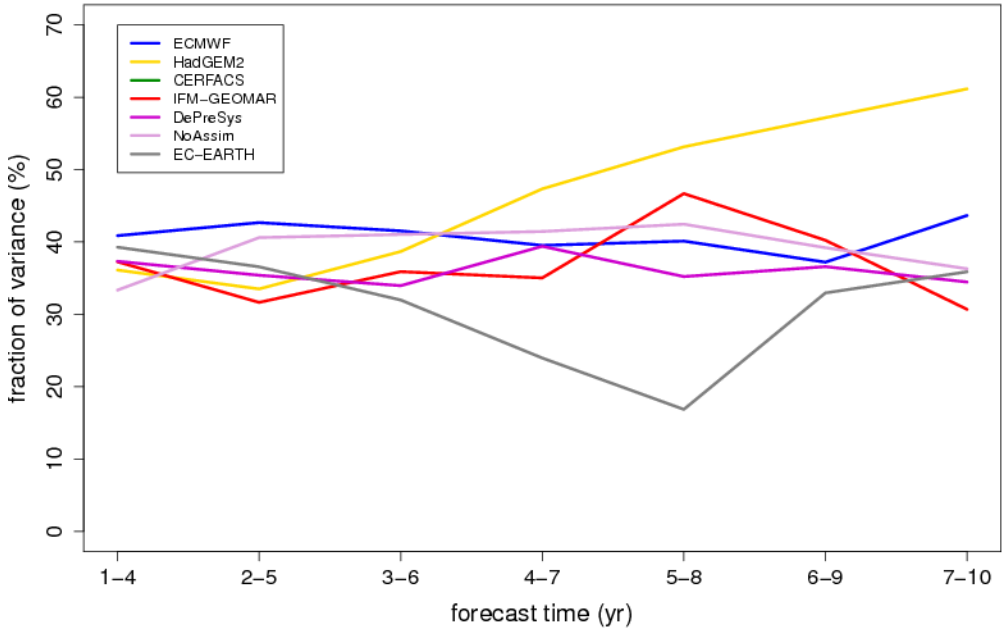
West African precipitation

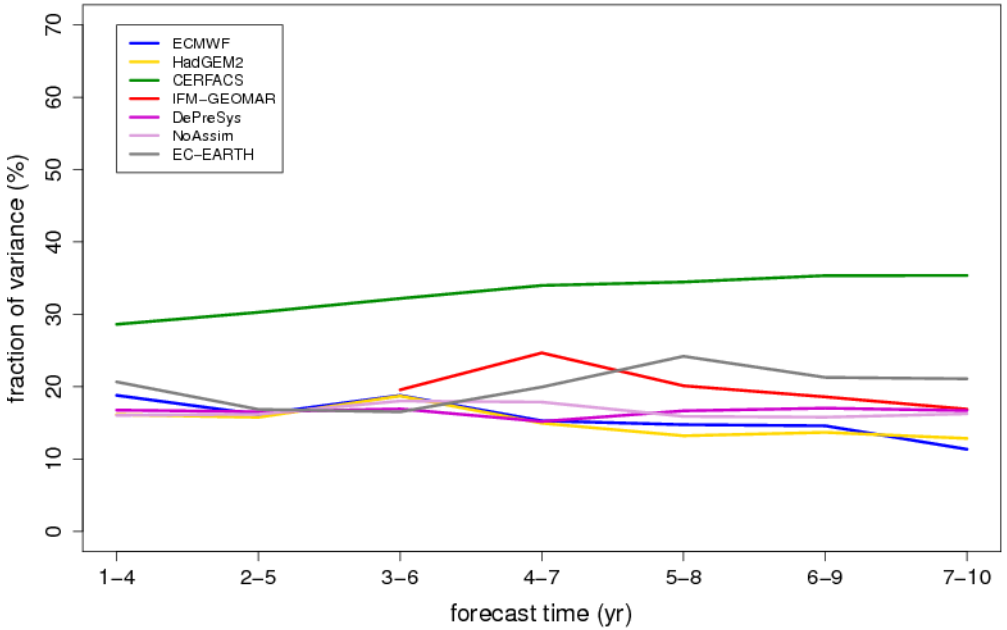
Spatial pattern and correlation with the SSTs of the two leading modes of the CRU JAS precipitation over the period 1960-2005.



West African precipitation

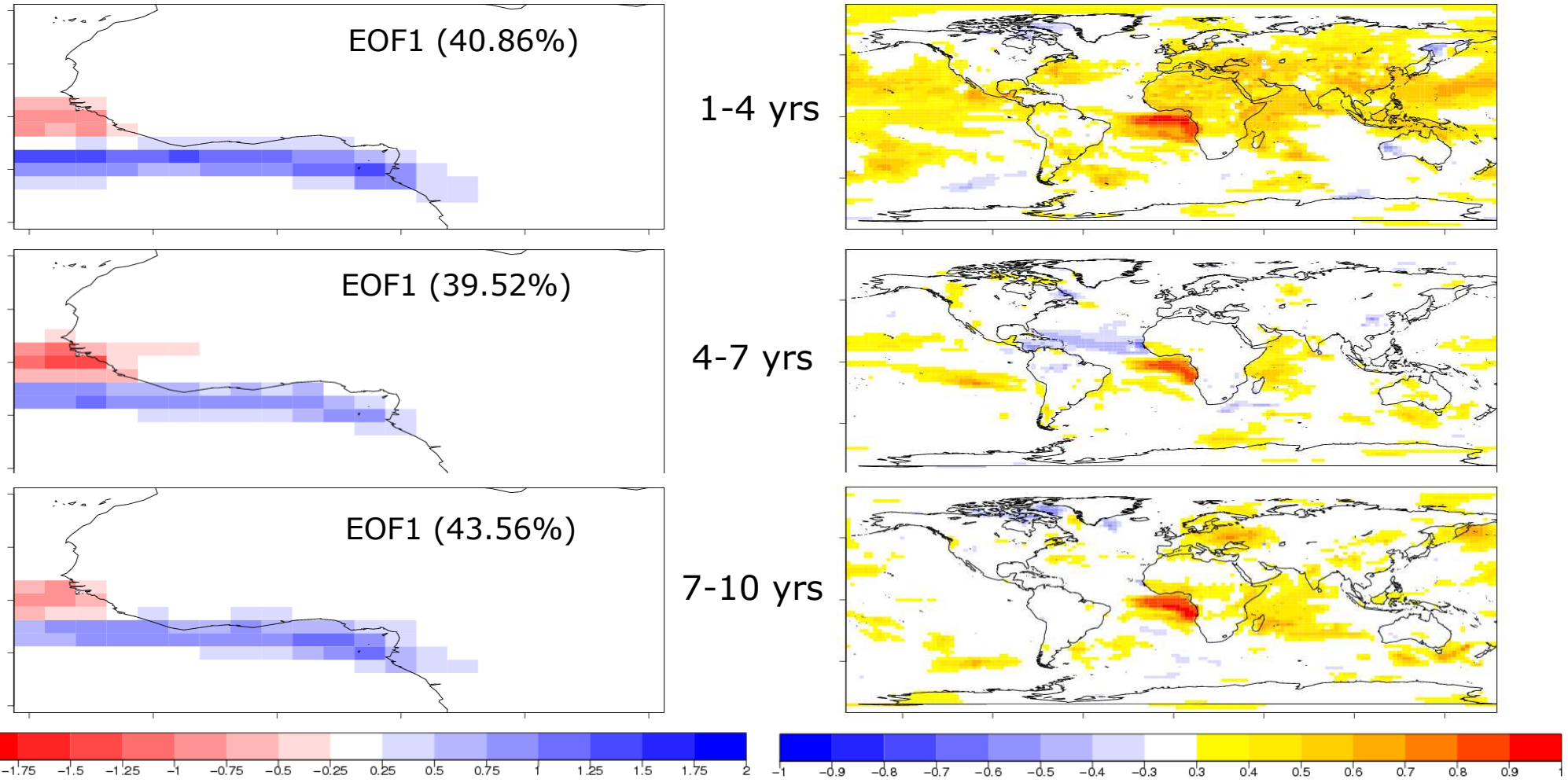
Fraction of variance of the Guinean (Atlantic Niño-related, left) and Sahel (AMO-related, right) JAS precipitation modes of variability.





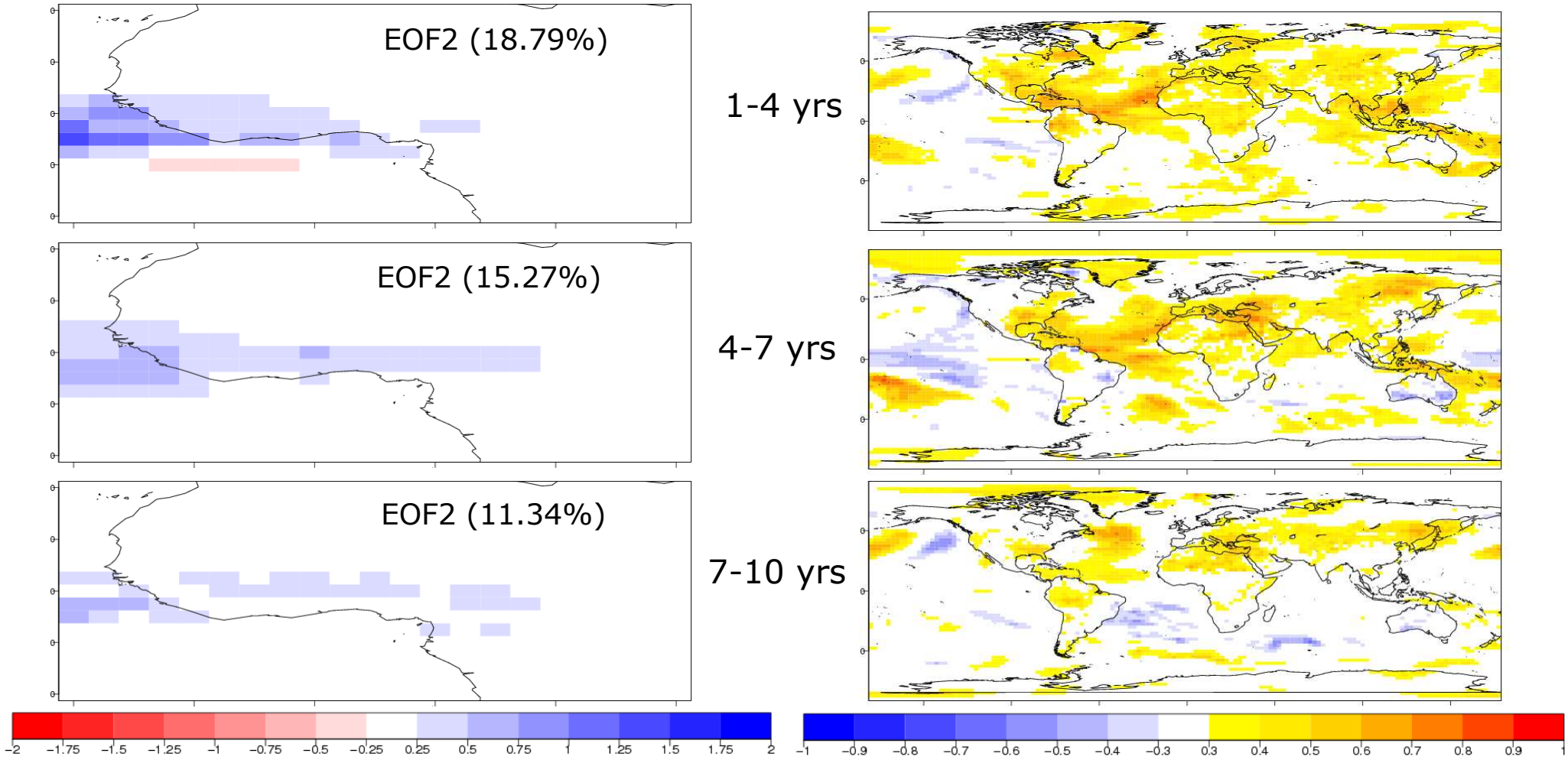
Modes of variability

Leading mode of West African JAS precipitation for the ENSEMBLES ECMWF experiment (left) and correlation with SSTs (right).



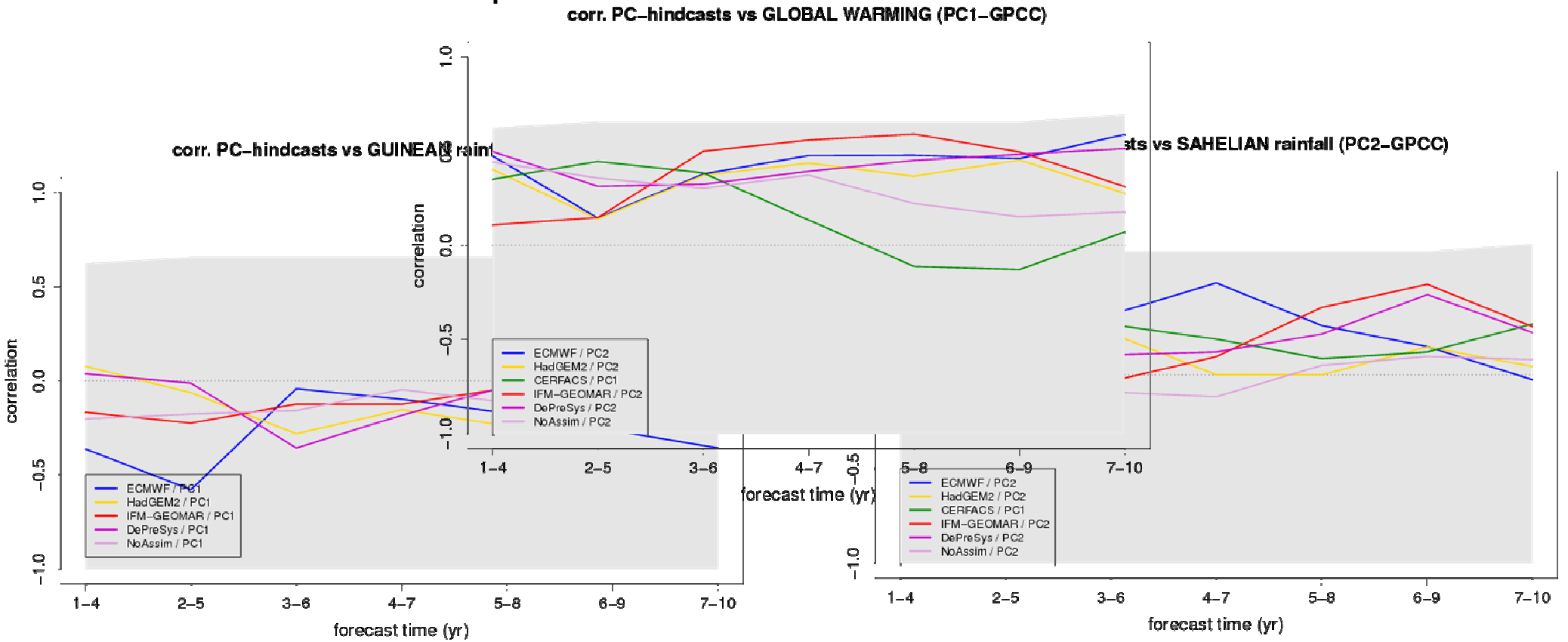
Modes of variability

Second mode of West African JAS precipitation for the ENSEMBLES ECMWF experiment and correlation with SSTs.



Modes of variability

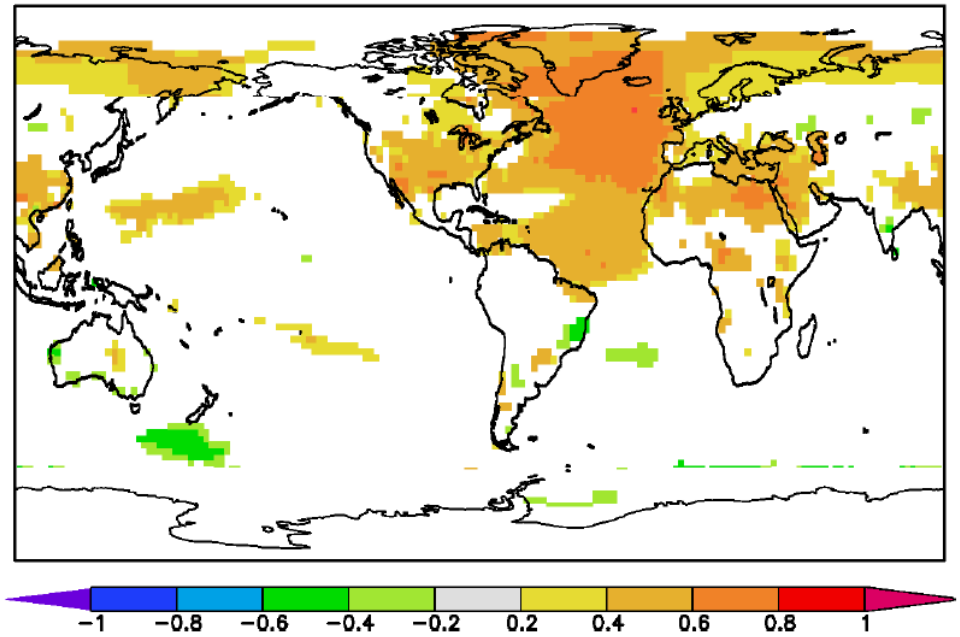
Ensemble-mean correlation with GPCC of the Guinean (left) and Sahel (right) modes of variability for the ENSEMBLES multi-model and DePreSys_PP Assim and NoAssim predictions. The grey band corresponds to the 95% confidence interval.



Modes of variability: AMO

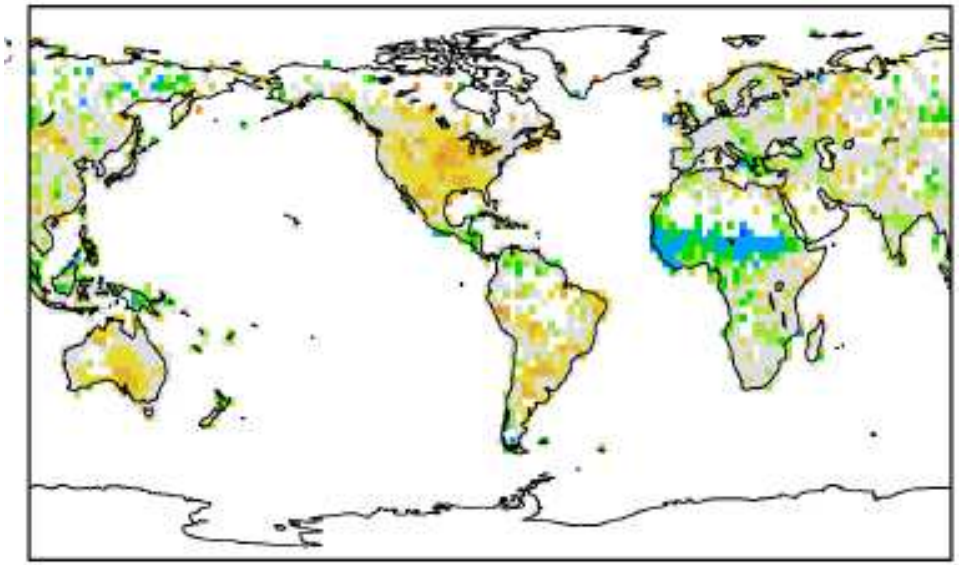
Observed AMO teleconnections.

AMO teleconnection



Temperature

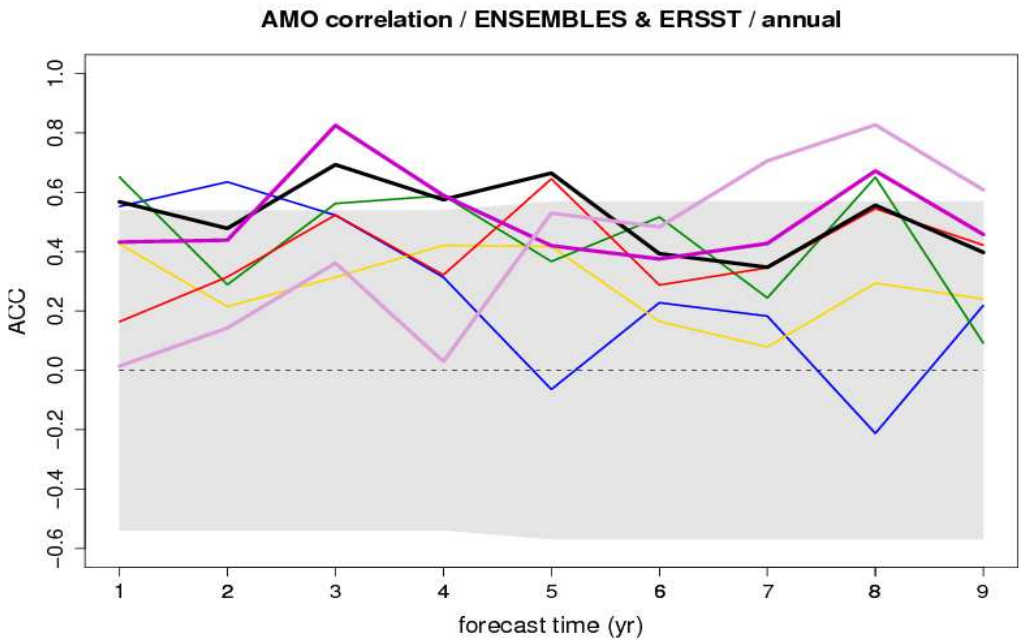
AMO teleconnections

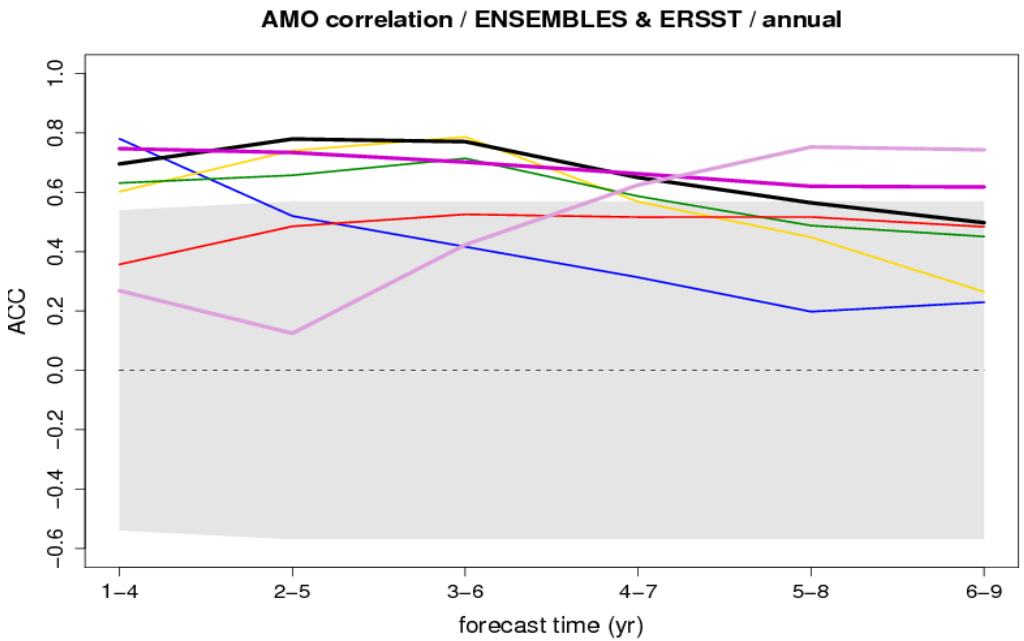


Precipitation

ENSEMBLES: AMO skill

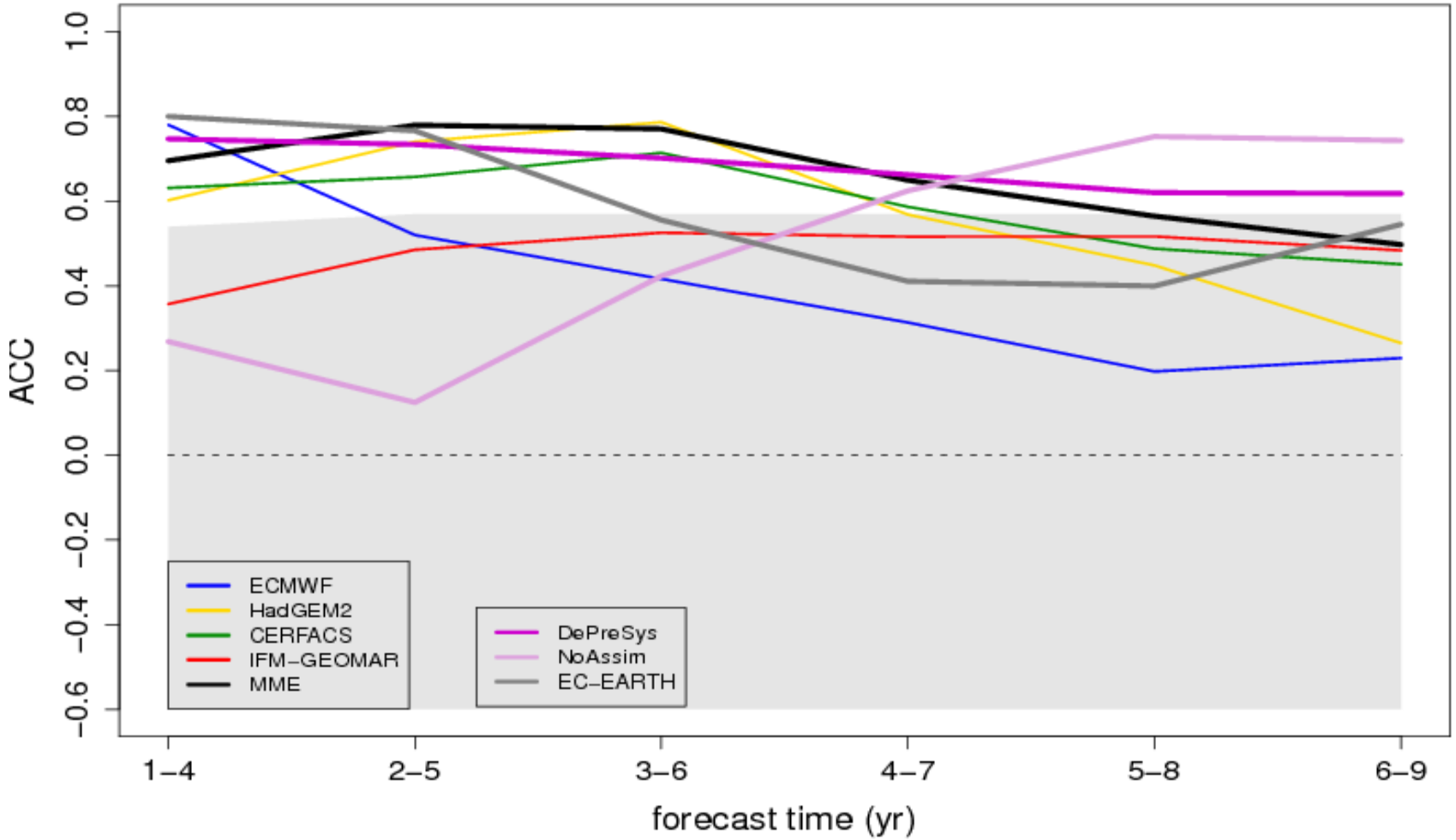
Annual-mean, ensemble-mean correlation for the AMO with respect to the ERSST. The grey band corresponds to the 95% confidence interval.





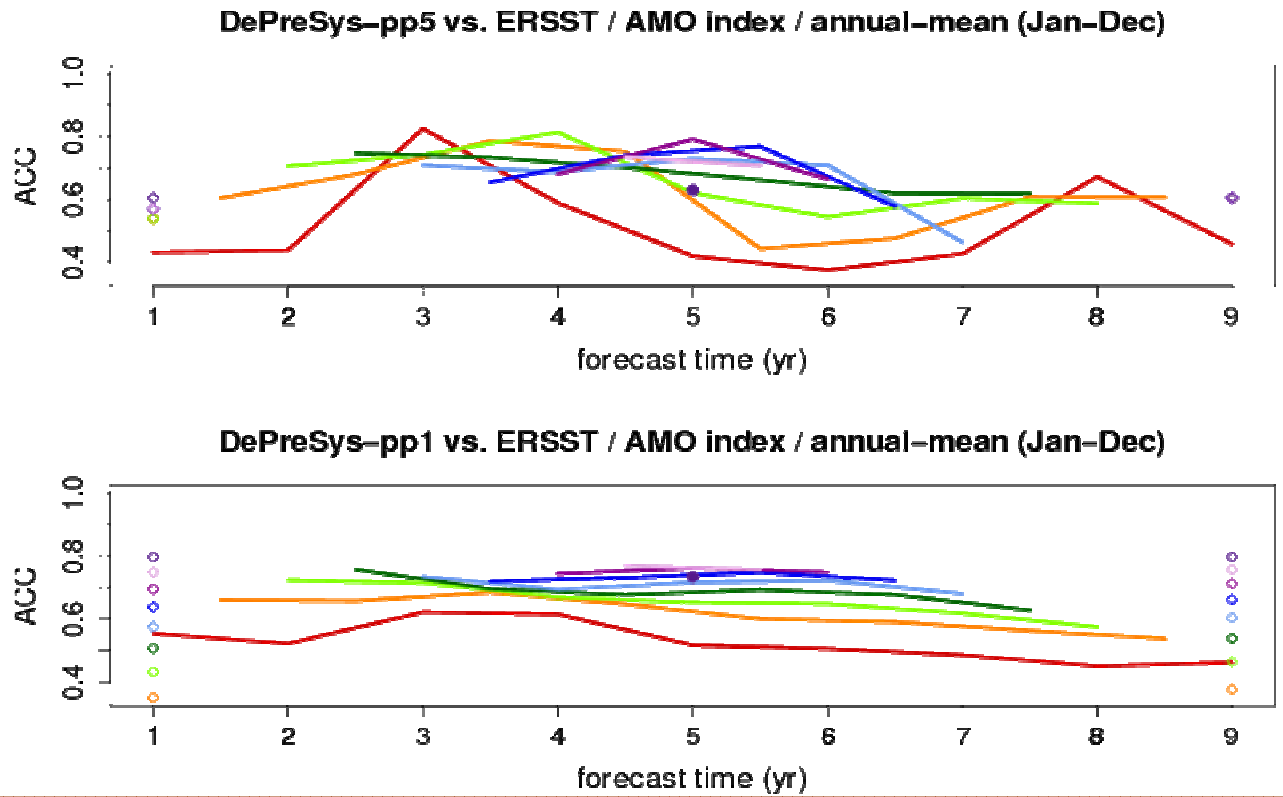
AMO decadal predictions

Annual-mean, ensemble-mean correlation for the AMO with respect to the ERSST. The grey band corresponds to the 95% confidence interval.



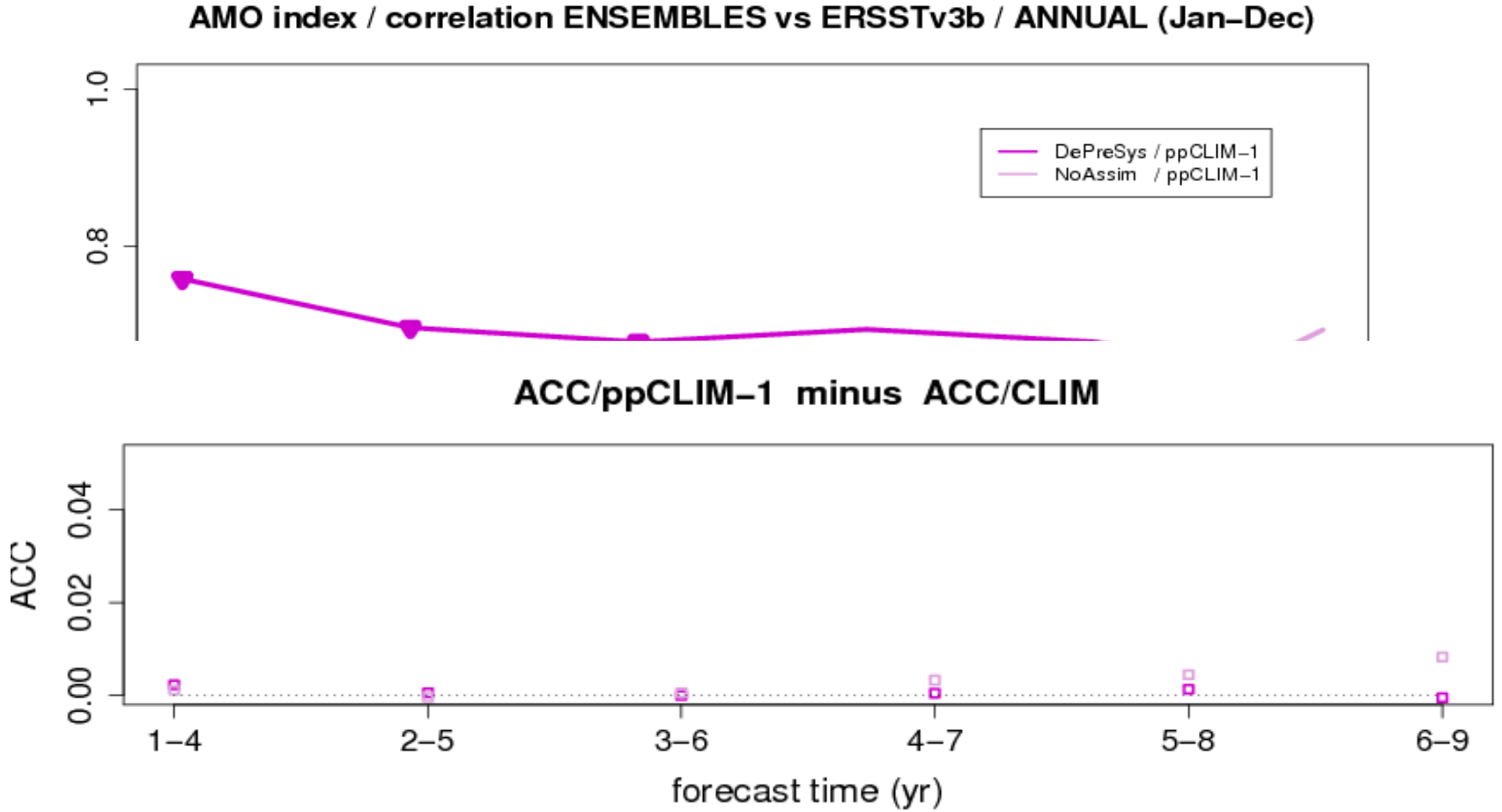
Impact of start date frequency

Annual-mean, ensemble-mean correlation with respect to ERSST for the AMO for DePreSys_PP Assim with one start date every five years (top) and every year (bottom). Each colour shows the result for a different degree of averaging, from red (one year) to purple (nine years).



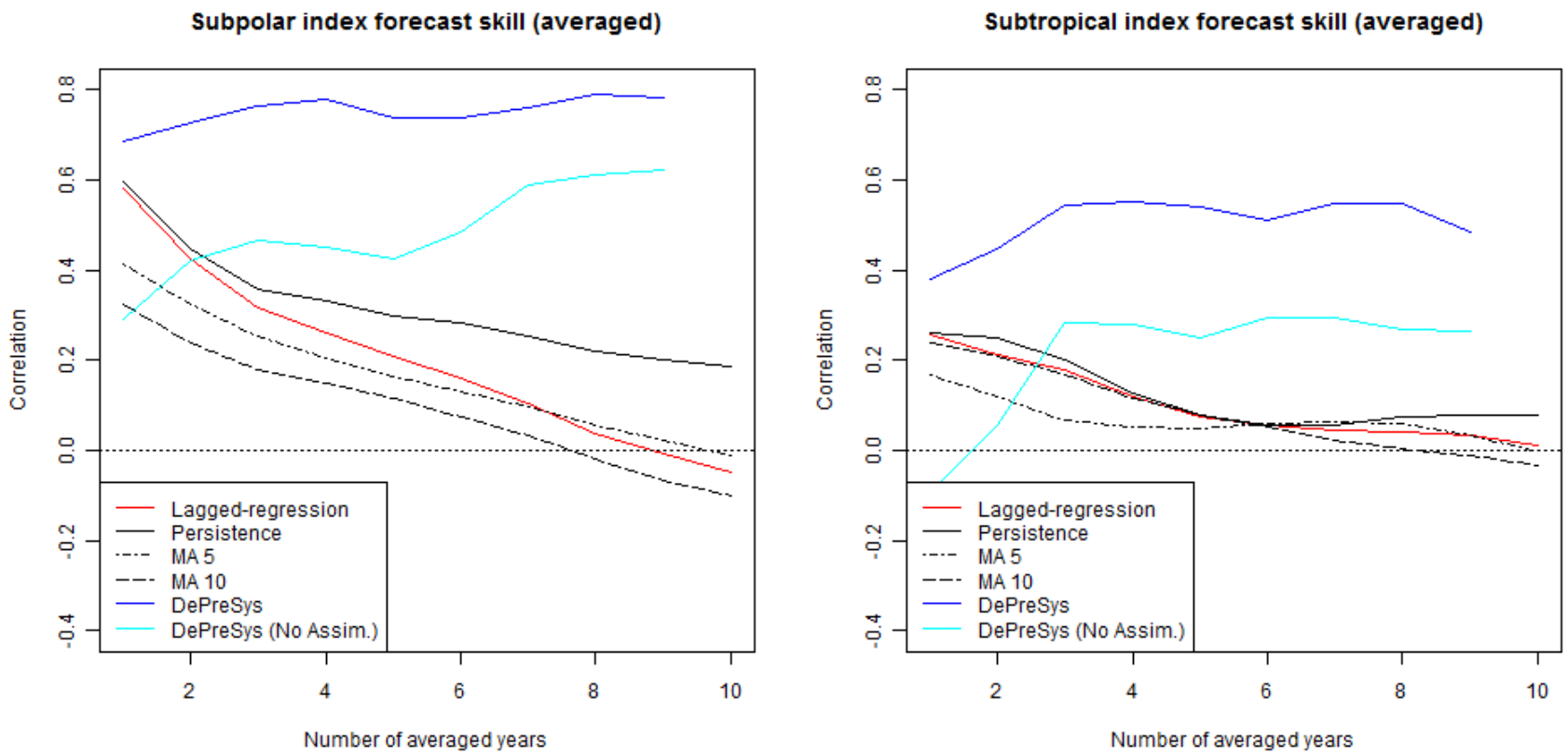
Impact of start date frequency

Annual-mean, ensemble-mean correlation with respect to ERSST for the AMO of DePreSys_PP Assim (purple) and NoAssim (pink) with one start date per year.



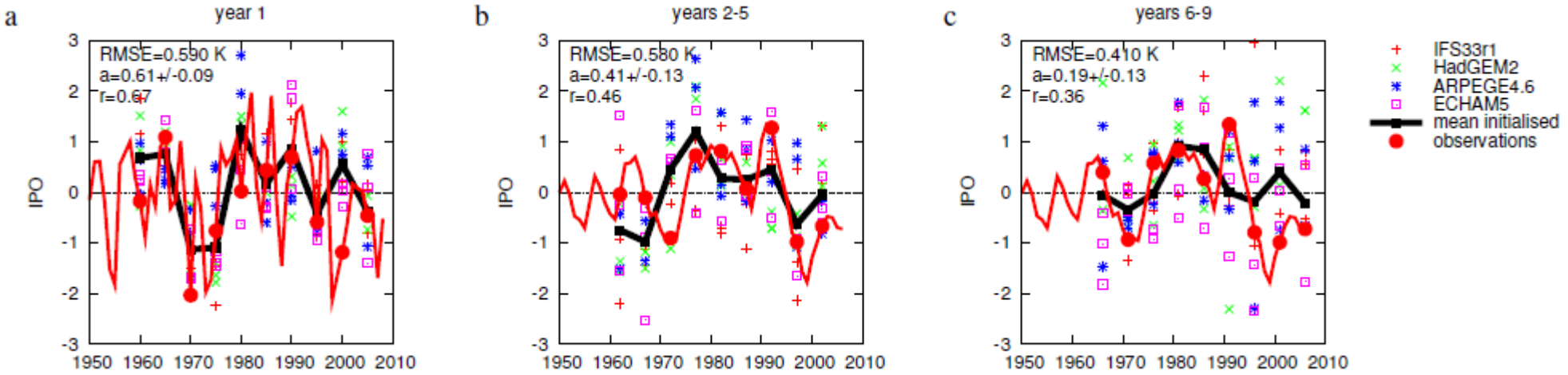
AMO empirical predictions

Annual-mean, ensemble-mean correlation with respect to ERSST of the subpolar and subtropical components of the AMO for DePreSys Assim (blue) and NoAssim (cyan) with one start date per year and a set of empirical predictions.



The Pacific: IPO predictions

Predictions for the first year and the averages for the forecast periods 2-5 and 6-9 years of the ENSEMBLES multi-model versus ERSST (red).



West African precipitation summary

- No significant skill has been found in the ENSEMBLES systems to predict the GUI and SAH rainfall indices.
- Different representation of WA precipitation in models.
- No significant skill has been found for the dominant rainfall regimes (GUI and SAH modes).
- Models SAH model shows also positive correlation with the observed global-warming (EOF1 in GPCC).
- Different systems have shown ability to predict the SST phenomenon driving the Sahel precipitation, the AMO.
- A comparison between DePreSys Assim and NoAssim suggests no improvement from initialization beyond year 5.
- Future: Explore multi-year skill for the Atlantic Niño.